LEGUMINOUS FORAGE PLANTS

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BY

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PREFACE

The chief object of this little book is to enable interested persons to recognize the more important leguminous plants grown on the farm, both in the seedling and in the mature stage. Most of the text-books on agriculture and agricultural botany give some account of these crops; but there is no convenient book in the English language which describes leguminous forage plants sufficiently well for the inexperienced individual ever to recognize them, largely because of the lack of suitable illustrations.

In this book every species described is illustrated, together with its seedling. All the illustrations are original, and have been drawn by me from living specimens taken either from the College Farm or the Botanical Garden. I have deliberately described the plants of lesser importance in some detail, since information concerning them is difficult to obtain by the average person.

As far as possible I have avoided technical terms, though the use of a certain amount of jargon is inevitable. The inclusion of a glossary should make the descriptions easy to follow. The book is intended mainly for students at Agricultural Colleges and Institutes, but I hope that it will be found useful by Advisory Officers, County Organizers and others interested in farm crops.

I have to thank the Chief Officer of the Official Seed Testing Station for permission to print the figures given in column one of the table dealing with Seed Statistics, and Mr. C. C. Brett, of the same Station, for helpful information. Messrs. Sutton and Sons, Ltd., kindly

criticized the figures given in this table, but the responsibility for its form and content is mine. Dr. R. Alun Roberts, of Bangor, kindly read through the manuscript and made some helpful suggestions.

D. H. R.

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LEGUMINOUS FORAGE PLANTS

CHAPTER I

GENERAL CHARACTERISTICS

All the leguminous forage plants cultivated in the British Isles belong to a sub-order of the Family, or Natural Order, Leguminosæ, called the Papilionaceæ because their flowers are thought to resemble a butterfly. The name Papilionaceæ, however, is not usually employed, the word Leguminosæ being commonly used.

Stem and Leaf. The plants are herbaceous, that is to say they do not become hard and woody after the manner of trees and shrubs. The leaves are always arranged alternately on the stem, and are made up of a common leaf-stalk and three or more leaflets, each with its own stalk or petiole. At the base of the main leaf-stalk is a pair of small leaf-like outgrowths, called stipules. These stipules vary considerably in size and shape, and in many cases are extremely useful in identifying leguminous plants not in flower.

Inflorescence. The flowers are usually combined into a characteristic flower-head or inflorescence known as a raceme. There is a central axis, upon which are arranged the individual flowers, each on its own short stalk or peduncle. If the inflorescence is at the end of the main stem of the plant it is said to be terminal: but it is more usual for the common flower-stalk to arise in the axil, or angle between a leaf and the main stem, in which case it is said to be axillary.

Flower. The flower of the Leguminosæ is peculiar and not easily confused with that of other Families (Fig. 1). The green calyx forms a tube at the base of the flower, and the individual sepals are recognizable only as 5 calyx teeth, the length of which relative to the tube varies in different flowers. Usually a distinct vein or nerve runs down the centre of each tooth, and occasionally 5 other veins can be seen between, and alternating with, them. The corolla is composed of 5 petals, of three different kinds. The posterior, or uppermost petal is comparatively broad, the free portion curving upwards at an angle to the other petals: it is called the Standard, or Vexillum. Next comes a pair of similar petals called wing-petals, or Alæ. Each wing-petal has a slender stalk, called the claw, and an expanded portion. Sometimes there is a distinct, backwardly projecting, finger-like process at the base of the expanded portion, as in Lucerne (Fig. 13D, p. 50). The wing-petals are free from each other.

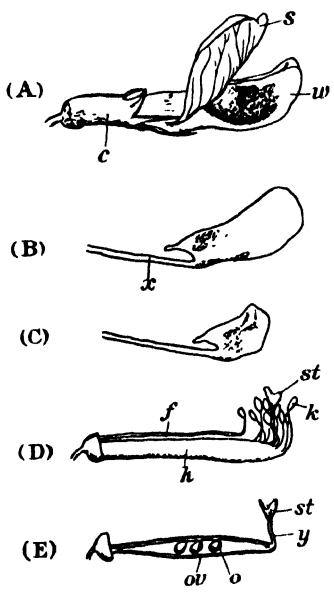

FIG. 1.—Flower of Field Bean.

A, complete flower: *c*, calyx; *s*, standard; *w*, wing-petal. B, a wing-petal showing claw *x*. C, single keel-petal. D, stamens: *f*, free stamen; *h*, stamen sheath; *k*, anther; *st*, stigma. E, carpel; *st*, stigma; *y*, style; *ov*, ovary; *o*, ovule.

More or less completely concealed by the wing-petals is a pair of keel-petals. These also have distinct claws, but the expanded portions are more or less united by their outer margins into a boat-shaped structure, the Keel or Carina, within which are hidden the essential parts of the flower.

Frequently, part of the inner surface of the wing-petal adheres to the outer surface of the corresponding keel-petal: in other flowers a projection from the wing-petal engages in a depression in the keel-petal, so that a movement of the wing-petal is at once transferred to the keel-petal.

Within the keel are the Stamens, and the Pistil, or Gynæcium. The stamens forming the Andrœcium have a very characteristic appearance because the ten stalks, or filaments, which support the knob-like anthers, are fused for the greater part of their length into a thin membranous sheath. This is the monadelphous arrangement. But in some plants the upper stamen has a stalk all to itself—the diadelphous arrangement.

Fruit and Seed. The pistil is surrounded by the stamens. It is composed of a single carpel consisting of a single ovary, with a single style ending in a stigma. There may be one or more ovules in the ovary. The ripe ovary forms a type of fruit called a Legume. It is usually a long, more or less cylindrical, or flattened pod, with two distinct sutures, or junction lines, running one along the top and the other along the underside. In some cases, when the pod ripens, unequal drying-out of the fruit walls sets up a twisting force, and the pod splits apart along the sutures, often with such violence that the seeds are thrown out quite considerable distances; Birds-foot Trefoil behaves in this way. Sometimes, as in White Clover, splitting takes place along one suture only, whilst in other plants no splitting at all occurs, the seeds being released by the decay of the ovary.

The seed is more or less rounded, with usually a smooth, polished seed coat. The hilum, or scar left by the stalk which originally fixed the seed to the ovary wall, is usually conspicuous (Fig. 2). Frequently there is a small coloured spot or wart-like swelling close to the hilum, on the side opposite to the micropyle: it is called

the strophiole. The reserve food is contained in the two cotyledons, and there is no endosperm, or food reserve outside the embryo, except in the Soya Bean.

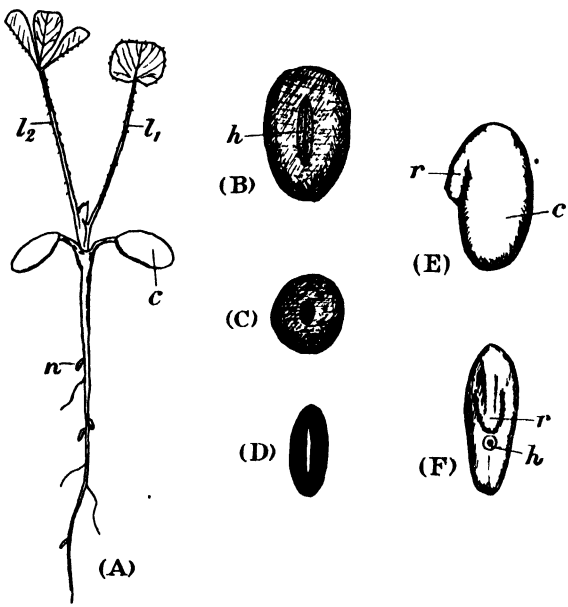

FIG. 2.—Seed and Seedling.

A, Seedling of crimson clover; *c*, cotyledon; l_1, l_2, first and second leaves; *n*, root nodule. B, C, D, seeds of field bean, field pea and common vetch showing different hilums. E, F, seed of red clover; *r*, radicle; *c*, cotyledons; *h*, hilum.

"Hard" Seeds. Many leguminous seeds, when placed in water, do not swell in the normal manner. This is because their seed coats are impervious for some reason, and the name "hard seeds" is applied in such cases. If a "hard" seed is scratched or pricked, water is absorbed, the seed swells, and germination can proceed. Various theories have been put forward to account for this impermeability, such as an excess of mineral matter in the seed coat or the presence of a waxy or waterproof

substance on the outside of the seed. Weather conditions and methods of harvesting undoubtedly play an important part in determining the percentage of hard seeds in a sample. Freshly harvested white clover may have as much as 30 to 40 per cent or more of hard seeds.

Under soil conditions hard seeds slowly lose their impermeability and a delayed germination occurs. Although in special circumstances this delayed growth may be a positive advantage, most farmers prefer not to have many hard seeds in a sample. It is an easy matter for a seed firm to scarify leguminous seeds to eliminate hardness, and this practice is commonly adopted.

Germination. Most leguminous seeds germinate in the usual manner, bringing their seed-leaves above ground.

The cotyledons are oval, thick, and regular in outline. They are never segmented or toothed like the foliage leaves, which are produced above the cotyledons. There is a definite hypocotyl between the cotyledons and the true root. Root nodules appear almost the same time as the first true leaves. But in the pea, bean and vetch the cotyledons remain buried.

Frequently the first true leaf produced from between the cotyledons differs very markedly from subsequent ones: this is of considerable value in identifying leguminous seedlings (Fig. 2).

Nitrogen Fixation. All parts of the plant, including the seed, are rich in nitrogen compared with non-leguminous plants. The reason for this was first explained by Hellriegel and Willfarth in September 1886. It is that leguminous plants are indirectly able to utilize the nitrogen of the air through the agency of bacteria which live on the roots of the plant. Normal leguminous plants bear on their roots numerous wart-like swellings or nodules, which are caused by a species

of bacteria called *Pseudomonas radicicola* (Fig. 3). The bacteria, which are normal inhabitants of the soil, penetrate the root hairs, and multiply within the root causing the nodules. They convert carbohydrate material intended for the use of the plant to their own purpose, and at the same time extract nitrogen from the air which fills the interstices of the soil, building it up into their own tissues. The bacteria are, up to this point, parasitic. But, later, the plant secretes an enzyme which dissolves

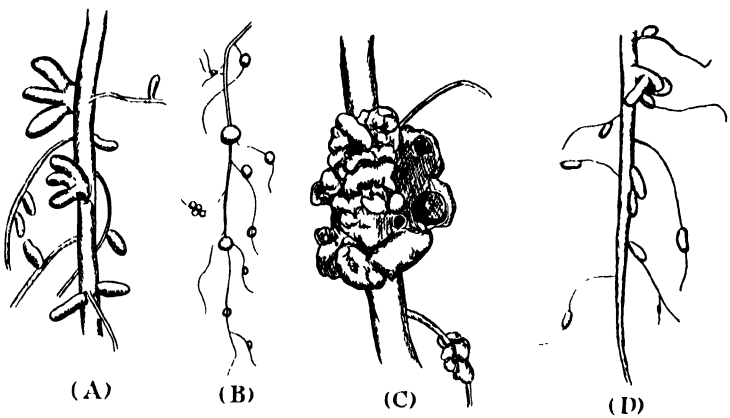

FIG. 3.—Root nodules of A, field pea; B, kidney vetch; C, lupin; D, white clover.

many of the bacteria, and the combined nitrogen is then used by the plant. The term symbiosis is usually given to this "partnership" between plants and bacteria.

Many of the bacteria escape back into the soil. When these die and when a clover root is ploughed under and decays, the soil becomes enriched with combined nitrogen which acts as a fertilizer to subsequent crops. The growth of leguminous crops therefore not only provides a fodder rich in nitrogen, but also forms a good preparation for non-leguminous plants, especially cereals. It

has recently been shown, too, that grasses growing in close proximity to clovers are stimulated by this extra nitrogen.

The root nodules differ in size and shape for each species of plant. They are large and roughly spherical in field beans and soya beans, small and lobed in white clover, large and rather cylindrical, often tri-lobed in peas. They develop very early in the life of the seedling, and can usually be seen shortly after the cotyledons emerge above ground.

The nodule-forming bacteria are specific. That is, they usually form nodules on one species of leguminous plant only. For example, the organism which attacks red clover will not infect the root of white clover, or peas, and *vice versa*. But our British soils usually contain sufficient of every type of organism to infect the roots of all leguminous crops except lucerne and soya bean. To get a satisfactory growth of these two plants in soil which has never carried the crop before, or in which a crop has not been grown for many years, it is necessary to add the requisite bacteria. This is done by inoculating the seed before sowing.

One method is to use air-dry soil from a field on which a successful stand of the plant has been secured; after sprinkling the seed with a solution of cane sugar in water, to make it sticky, the powdery soil is dusted over the seed, which is repeatedly turned.

The more modern method is to use a special culture of the correct organism which is applied to the seed (see p. 54).

It is important that when the seed is drying it is not exposed to direct sunlight, for this kills the bacteria; neither should sowing be too long delayed after inoculation.

Cultivated Plants. Leguminous forage plants belong to several different Genera within the family.

The following include all the leguminous forage crops of any importance in this country:

Genus *Trifolium*—True Clovers
Genus *Medicago*—Lucerne and Trefoil
Genus *Onobrychis*—Sainfoin
Genus *Lotus*—Birdsfoot Trefoil
Genus *Anthyllis*—Kidney Vetch
Genus *Melilotus*—Sweet Clover
Genus *Lupinus*—Lupins
Genus *Faba*—Field Bean
Genus *Vicia*—Vetches
Genus *Pisum*—Field Pea
Genus *Glycine*—Soya Bean

CHAPTER II

TRUE CLOVERS—GENUS *TRIFOLIUM*

General Characters of the Genus. Clovers are herbs, with trifoliate leaves. The margins of the leaves may be entire, or toothed, but the tip is free from the sharply pointed projection so characteristic of the Medicks (see p. 48). The stipules have entire margins; they are never toothed as in the Medicks. The flowers are red, white or yellow, in close, usually spherical or globose heads. The petals are long and narrow, and together with the sepals usually remain round the pod after withering. The upper stamen is entirely free (diadelphous). The pod is small, containing from 1 to 4 seeds. The seed is rounded, highly polished, and the position of the radicle is more or less clearly defined.

In all cases, the seedling is sturdy, with the two fleshy cotyledons coming above ground. The first true leaf is simple and almost circular: all subsequent leaves are trifoliate (Fig. 2, p. 4).

The following are the most important species of clover used in this country:

Red Clover (*T. pratense*)
Alsike Clover (*T. hybridum*)
White Clover (*T. repens*)
Crimson Clover (*T. incarnatum*)
Yellow Suckling Clover (*T. dubium*)
Subterranean Clover (*T. subterraneum*)
Strawberry Clover (*T. fragiferum*).

RED CLOVER

(*Trifolium pratense* L.)

General Characters. Members of this species are short-lived perennials. The root is a strong tap-root with numerous fine lateral branches. Both the main root and the branches bear small cylindrical nodules a few millimetres long, attached at one end.

From the crown of the plant spring numerous more or less erect stems, which may be solid or hollow. Some

FIG. 4.—Red clover plant showing the stipules and flower-head.

types of red clover have solid stems which become hollow after flowering. The trifoliate leaves are carried on short stalks, and each leaflet has its own, very short petiole: all three of these petioles are the same length. The leaflets are oval, elliptical or ovate: there is usually, but by no means always, a curved or crescent-shaped area of lighter green on the upper surface. The margin of the leaf is never toothed. The plant as a whole may be very hairy or almost entirely glabrous (free from hairs).

The stipule is broad, but ends abruptly in a short, sharp point (Fig. 4). The veins are conspicuous, purplish-green in colour.

The flower-head is globular, and in cultivated types is borne upon a short stalk, below which are two leaves with extremely short stalks, situated very close together. The flowers are crowded together on this head, and

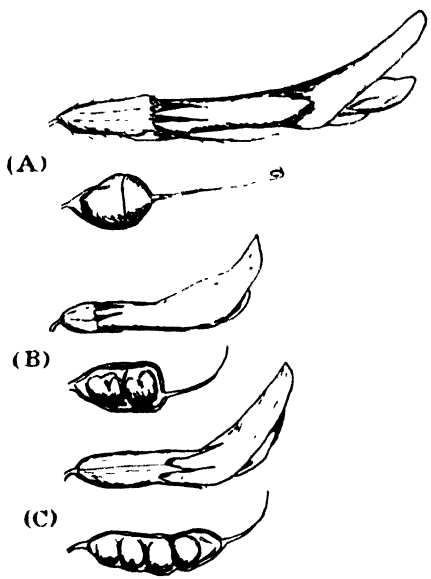

FIG. 5.—Flower and fruit of A, red clover; B, alsike clover; C, white clover.

number about 27 on an average. They vary from a pink to a mauve; shades of red and purple are commonest, but white flowers are occasionally met with.

The calyx has 5 teeth and 10 nerves, and is hairy: the lower tooth is almost twice as long as the other four (Fig. 5). The corolla forms a long, narrow, closed tube at the base: the tube, which is about 10 mm. long, is composed of the fused claws of the 5 petals, which unite with the sheath of the 9 united stamens. Nectar

is secreted from the base of the tube, and collects around the ovary. Nine of the stamens are united, but the upper one is entirely free. The ovary is short and thick, with a long, slender, straight style. There are 2 ovules in the ovary, but only one forms seed. The fruit is a thin-walled, egg-shaped structure with one seed, enclosed in the brown, shrivelled calyx and corolla. The pod splits transversely and the two halves separate to release the seed: it is called a pyxidium. Seeds are often met with still carrying the upper part of the pod attached to the broad part of the seed, like a close-fitting cap.

Seed and Seedling. The seed of red clover is a slightly flattened oval, on an average rather more than 1·5 mm. long by about 1·0 mm. broad: larger and smaller seeds, of course, are common. The radicle forms a distinct projection at the broader end (Fig. 2E), which is usually more or less violet or purple in colour, shading to yellow at the narrow end. Most samples of red clover seed contain numerous seeds which are entirely yellow, or brown, with no trace of purple. As is the case with all seeds, the colour darkens with age, and the highly polished brightness of freshly harvested seeds diminishes during storage. Further details concerning the seed are summarized in the table on page 111.

The seedling[1] has large cotyledons on short, stout stalks. The cotyledons are of a rounded oval shape, about 5·5 mm. long by 4·0 mm. broad: the stalks are 1·5–2·0 mm. long. The first leaf is rounded and hairy, and the veins on the upper surface are indistinct (Fig. 12D, p. 46).

[1] The descriptions of the seedlings given here and elsewhere refer to the young plants after the first leaf has appeared, but before the development of the second leaf. The measurements are only approximate, since considerable variation occurs. As the seedling gets older, a general increase in the size of the cotyledons and first leaves takes place.

Red clover ripens its pollen before the stigma of the same flower is ready to receive it. Recent investigations have shown that red clover is almost completely self-sterile, although a few artificially self-pollinated flowers have been found to set seed. In nature, cross pollination is carried out by bees. In this country bumble-bees are the usual agents, and although hive bees are capable of carrying out the process they do not usually visit red clover flowers in sufficient numbers to influence seed setting. In other countries hive bees are relatively more important. When red clover was first introduced into New Zealand it failed to set seed owing to the absence of suitable insects: the importation of live bumble-bees enabled seed crops to be grown.

In the hybridization of red clovers bumble-bees are frequently employed. They are gently washed in a tube of distilled water to remove any pollen from their bodies, and are then released under a gauze cage containing the two plants it is desired to cross. Owing to the almost complete self-sterility of the plants it can be fairly safely assumed that any resultant seed is a cross.

The diploid number of chromosomes is fourteen.

History. Although red clover has been known for many hundreds of years and has been cultivated on a small scale since the fifteenth century, it did not make much progress as a farm crop until the eighteenth century. It was introduced into England by Sir Richard Weston in 1633, and into America about 1790. With the disappearance of the old manorial systems of farming and the development of new rotations during the eighteenth century, red clover began to assume greater importance in British agriculture. Stebler claims that the development of red clover as a farm crop has had an influence on rural and national life even greater than that of the potato.

Cultivated Types. There are three main types of red clover:

1. Wild Red Clover (*T. pratense spontaneum*).
2. Early Flowering Red Clover (*T. pratense præcox*).
3. Late Flowering Red Clover (*T. pratense serotinum*).

1. Wild Red Clover, or Indigenous Red Clover, flowers very early, usually in April and May. It is smaller than the other types, with a few short, slender, wiry stems. The leaves are dark green and, owing to the length of the upper internodes of the stem, are widely spaced, giving the plant a leafless appearance. The stems are usually solid and more or less prostrate.

Wild red clover lasts longer than any of the other clovers, but its yield is scanty, and it is not very palatable. It ceases growth during the winter. It adds very little to the hay and gives no aftermath: it is more of a grazing plant.

This clover, which exists in a great variety of forms, is at present not worth sowing by the average farmer.

2. Early Flowering Red Clover, or Broad Red Clover, flowers about the middle of June, from 10 days to 3 weeks earlier than the late flowering types. It also flowers in the aftermath. There are from 3 to 6 stems per plant under field conditions: these are hollow, with from 5 to 7 internodes at time of flowering. The leaves are broader than those of the late flowering types. Owing partly to the side branches flowering at the same level as the main stems, the plants appear more erect than the late varieties.

Broad red clover grows rapidly from seed, and after the removal of the nurse crop—usually barley or oats—recovers very quickly and affords winter grazing. The following spring it recommences growth early, and after

being cut for hay, springs again and flowers in the aftermath. Many types of broad red clover are then exhausted, and die away rapidly, giving practically no return in the second harvest year. Strains from the western districts may persist better than those from the eastern districts.

Broad red clover is most suited to one-year leys in the eastern counties. In other parts of the country, especially in the north and along the western seaboard, it is not so reliable as the late flowering types.

Numerous strains of early flowering red clover are now on the market, but all the available evidence goes to show that English- and Welsh-grown strains are superior to foreign strains, and that strains from the northern temperate districts are better than those from southern Europe and America.

Amongst the best native strains are English Broad Red from the Cotswolds and Eastern Counties, Dorset Marl, Vale of Clwyd Early Red, and Vale of Glamorgan Red.

Of the foreign strains, Chilean red clover is perhaps the best, but it is not so hardy as English strains. American Medium, Canadian Broad Red, and New Zealand Broad Red give good bulk, but the quality and winter keep are inferior.

3. Late Flowering Red Clover, still called single-cut Cowgrass in many parts of the country, seldom flowers twice in the season. It has more stems than early flowering red clover, from 5 to 15 under field conditions, and is more tufted in growth. The stems have more internodes (7 to 15 at time of flowering with 6 to 7 as an average), and are solid until after flowering has taken place, when they frequently become more or less hollow. They are longer and weaker than those of broad red clover. The leaves are narrower. There are

more side branches, especially towards the top of the stems.

Late flowering red clover does not usually flower in the seedling year, and flowers only once each succeeding year. It starts growth rather slowly in spring, but produces a tremendous bulk of hay, outyielding the early flowering kinds in this respect; it yields comparatively little aftermath. On the other hand, the late flowering red clovers are more hardy, less susceptible to clover rot, and longer lived than the early flowering types. They also stand up better to the grazing animal. They may persist for six or more years, but their yield after the first three or four harvest years drops very rapidly. Late red clover is more adaptable than early flowering red clover, and is generally superior to it on soils of moderate fertility, even for one-year leys.

Late flowering red clover will often yield satisfactorily on land which will not support the early flowering type. The introduction of late flowering red clover into certain areas in Devonshire, for example, has made it possible to obtain much better crops of hay than were common when early flowering red clover was used.

English strains are preferable to foreign seed, being more reliable and more productive. Strains from Essex have proved very suitable for one-year leys on rich soils in the Eastern Counties, whilst Cotswold strains are very reliable croppers for all types of soil.

Montgomery late flowering red clover is an extra late flowering strain with an extremely wide range of adaptability to soil and climatic conditions. It is the most persistent type. Cornish Marl has similar characteristics.

American Mammoth, a very hairy variety with huge leaves, has given fair crops in Eastern and Southern districts; Swedish and Norwegian strains have such a short growing period that their use is not recommended.

Identification of Plants and Seed. Despite what

has been said to the contrary, it is not possible to identify individual plants of red clover as early-flowering or late-flowering. The mere appearance of stem, leaf and flower does not provide a reliable guide; identification depends more upon the habit of growth, number of internodes and colour of the flower, and time of flowering: to distinguish the two types it is necessary to see a number of plants growing in the field or garden.

Neither is it possible accurately to distinguish between the seeds of wild red, early flowering red and late flowering red clover.

Samples of home-grown seed, which is usually harvested in worse climatic conditions, contain more brown seeds and fewer yellow seeds than foreign samples. Home-grown seed is larger and heavier than most foreign seed except Chilian. According to Stapledon, Chilian seed weighs about 2·24 grammes per 1,000 seeds; British 2·0 gr., Canadian 1·63 gr., Italian 1·69 gr., French 1·55 gr. Most foreign samples contain seeds of lucerne, and if seeds of this plant together with chicory and ox-tongue (*Picris echioides*) are present in a sample, it is highly probable that the red clover seed is not entirely of British origin. Dodder should be, and usually is, nowadays, entirely absent from red clover seed. Ribgrass, or Narrow-leaved Plantain, and Dock seeds are universally found in samples of red clover seed.

Uses. Red clover is sometimes sown alone at the rate of 16 lb. per acre. But owing to the prevalence of clover-rot, or the possibility of having a badly tangled crop, it is more usual to mix rye-grass seed with the clover seed, using from 5–10 lb. of clover seed and from 7–16 lb. of either perennial or Italian rye-grass.

For leys above two years' duration late flowering red clover only should be used at the rate of from 2–6 lb. per acre.

Red clover must not be sown on the same land oftener

than once in eight years owing to the danger of "clover sickness," caused either by the fungus of clover rot (*Sclerotinia trifoliorum*) or by the eelworm (*Anguillulina dipsaci*). Where the old Norfolk 4-course rotation is fairly strictly adhered to, a trefoil ley is alternated with a red clover ley in order to obtain the necessary separation in time.

Red clover will not succeed on land deficient in lime. If the *p*H is below 5·5, the soil will not grow red clover. Red clover responds readily to phosphatic manures.

Seed Production. When early flowering red clover is grown for seed the first growth is cut for hay, or fed off by sheep until the beginning of May. The first cut is generally useless for seed, as there are so few bumble-bees about. A seed crop which follows sheep is earlier than that which comes after a hay crop, and is said to be of better quality.

When the heads on the leading shoots are brown and rub out easily the crop is ready to cut. This is in August or September. The lateral shoots mature later, and must not be taken into consideration. The cobs are stacked in long, narrow stacks until thrashed.

The yield of seed is extremely variable, from 2–13 bushels per acre according to season. An average crop is 260 lb. per acre.

Late flowering red clover cannot be grazed or cut for hay before taking a seed crop, as it flowers only once a season. The yield of seed is almost the same as for early flowering red clover.

In order to maintain the high reputation of their special strains of red clover, growers in certain parts of the country have formed Associations. There are in existence the Montgomery Late Flowering Red Clover Growers, Ltd., the Cornish Marl Clover Growers' Association, Ltd., and the Vale of Clwyd Red Clover Growers' Association.

Chemical Composition. The following percentage analyses of red clover are due to Kellner-Fingerling [1] (digestible nutrients in brackets).

	Dry Matter	Crude Protein	Crude Fat	N-free Extract	Crude Fibre
Green (in bud) . .	15·9	3·3 (2·4)	0·6 (0·4)	6·8 (5·5)	3·8 (2·3)
Green (beginning of flowering)	19·0	3·4 (2·5)	0·7 (0·5)	8·1 (6·3)	5·2 (3·0)
Green (in flower) .	21·0	3·4 (2·2)	0·7 (0·4)	9·4 (6·7)	5·9 (2·6)
Hay (good)	83·5	13·5 (8·5)	2·9 (1·7)	37·1 (26·0)	24·0 (11·3)
Hay (washed by rain) .	84·0	11·9 (6·1)	1·5 (0·7)	30·5 (18·3)	33·1 (13·2)

Fagan shows the superiority of the leaf over the stem and flower-head with the following percentage figures, calculated upon the dry matter of the hay of Montgomery late flowering red clover.

	Crude Protein	Ether Extract	Soluble Carbohydrate	Fibre	Ash	Lime (CaO)
Stem	8·19	1·33	35·42	49·10	5·96	1·797
Leaf	21·56	4·35	34·53	28·70	10·86	2·841
Flower-head . .	22·13	2·30	40·79	26·10	8·68	1·658

[1] The Kellner-Fingerling figures quoted here and elsewhere are those given by Becker in his "Handbuch des Hülsenfruchterbaues und Futterbaues," Berlin, 1929.

ALSIKE CLOVER

(*Trifolium hybridum* L.)

General Characters. Alsike clover is a perennial plant, having a life of from 3 to 5 years. Its habit of growth is similar to that of late flowering red clover. It is an upright-growing plant entirely free from hairs.

FIG. 6.—Alsike clover: the shape of the stipules and length of the flower-stalk should be compared with those of red clover (Fig. 4).

The root system is extensive, but closer to the surface than in red clover. The leaves are on longish stalks. The stipules at the base of the common footstalk are much longer than those of red clover, and taper gradually to a long-drawn-out point: frequently the basal portion develops an ear-shaped expansion which partly embraces the stem (Fig. 6).

The leaflets have a distinctly toothed margin, and lack the lightish coloured crescent usually found on red clover leaves. They are intermediate in shape between those of white clover and red clover and are of a lighter green than those of the latter.

The flower-heads are axillary (p. 1) and borne on stalks which are always longer than the leaf-stalks. There is no leaf immediately under the head as in red clover. The head is globular, composed of numerous pinkish-white flowers on longish stalks, which after fertilization become brown and shrivelled and turn downwards after the fashion of white clover.

The calyx tube is very short and has 5 narrow teeth of equal length (Fig. 5B, p. 11). The petals are quite free from each other, not fused into a tube as in red clover. There is a broad, rounded, backwardly projecting appendage where the claw and expanded portion of the wing-petal meet. The wing and keel-petals on either side adhere to each other at a spot close to this appendage. Fertilization is carried out by honey bees. The ovary contains two or three ovules.

Seed and Seedling. The seed is heart-shaped since the radicle occupies nearly as much space as the cotyledons (Fig. 34, p. 112) and the fruit is a broad, short pod with 2 to 3 seeds; seed is slightly larger than that of white clover but only half the size of red clover seed. It measures approximately 1 mm. in length. The general colour is bright green, often slightly marbled, but this darkens rapidly with age until the seed is almost black.

The seedling has small oval cotyledons approximately $3{\cdot}5 \times 2{\cdot}0$ mm., situated on stalks about as long as the cotyledons. The first leaf is almost square, with backwardly projecting points at the base. The veins are indistinct on the upper surface except at the margins. All parts are free from hairs. The stipules to the first

leaf are narrow and pointed, about 2 mm. long (Fig. 12B, p. 46).

History. Alsike clover derives its name from the village of Alsike, close to Uppsala, in Sweden, where it was first cultivated. It was first imported into England by a certain George Stevens in 1834, and during the last 100 years its cultivation has spread over most of the country. It is not a hybrid, as its scientific name implies, but a true species. Linnæus considered it to be a hybrid between red clover and white clover, but this is not so. The diploid number of chromosomes is 16.

Uses. Alsike clover has a shorter period of growth than red clover, but it is more adaptable. Besides doing well on all soils which support red clover it will grow in circumstances quite unfavourable to the latter; it stands up to wet and acid conditions much better, and is much less susceptible to both clover rot and stem eelworm. It is as hardy as the best strains of red clover. It is more succulent, and takes longer to cure than red clover hay. Its yield is not quite that of red clover. Alsike clover is not usually sown alone, but occasionally 8–12 lb. per acre of this species constitutes the sole seeding.

For short leys on damp and heavy soils alsike and timothy combine well: on more normal soils alsike and cocksfoot go well together. If alsike is the only clover to be included in these short leys, from 5–7 lb. of seed per acre are sufficient. In longer leys it is customary to use only $1\frac{1}{2}$–$2\frac{1}{2}$ lb. of seed per acre.

Owing to the similarity of growth between alsike clover and late flowering red clover, these two are unlikely to do well if both are included in large amounts in the same seeds mixture. It must be remembered that a pound of alsike seed is likely to give rise to twice as many plants as a pound of red clover seed of the same germination capacity.

Alsike clover, if grazed or fed green, is even more liable to cause "bloat" or "hoven" than red clover unless care is taken to prevent stock from eating too much of it.

Seed Production. Alsike clover is not so variable as red clover, and little attention has so far been directed to the separation out of different strains. Most of the commercial seed used in this country comes from Canada, and very little seed is grown here.

Chemical Composition. The percentage composition of alsike fodder is given by Kellner-Fingerling as follows (digestible nutrients in brackets).

	Dry Matter	Crude Protein	Crude Fat	N-free Extract	Crude Fibre
Green (beginning of flowering)	17·8	3·7 (2·4)	0·7 (0·5)	6·3 (4·5)	5·5 (2·9)
Green (in full flower) .	18·2	2·8 (2·1)	0·7 (0·5)	7·0 (5·2)	6·2 (3·5)
Hay (in full flower) .	84·0	13·6 (8·3)	3·1 (1·3)	34·5 (23·8)	25·7 (13·1)

WHITE CLOVER

(*Trifolium repens* L.)

General Characters. White clover is a perennial plant easily distinguished from all other commonly cultivated clovers on account of its creeping stem. This is solid, and grows close to the surface of the ground, sending out fibrous white roots at the nodes, or portions from which arise the leaves and flower-stalks (Fig. 7). These prostrate stems radiate from the crown of the plant which is situated at the top of a strong tap-root system. White clover has therefore an extremely

well-developed root system of two kinds, a tap-root system and an adventitious root system; this enables it to withstand drought to a remarkable degree. The root nodules are very small and sausage-shaped, attached by the longer side (Fig. 3D, p. 6).

The leaves are carried at the end of long, wavy stalks

FIG. 7.—White clover plant, showing the prostrate stem and the length of the flower and leaf-stalks.
f, fertilized flowers; *s*, stipule.

arising at right angles to the stem. The leaflets are variable in shape, sometimes heart-shaped with a notch at the apex, sometimes elliptical. The margin is toothed, and there is usually a lighter green crescent-shaped area on the upper surface. The leaves, like the rest of the plant, are hairless. The stipules are small and sharply pointed.

Each flower-head is borne at the end of a stalk, longer

than the leaf-stalk. Flower-heads are produced from May to July: at other periods the runners bear vegetative buds only. The head is globose, but rather flatter on top than in red clover, composed of numerous white or whitish-pink flowers, on short stalks. There may be from 10 to 80 flowers in the head. Usually the flower-head appears to consist of two parts, an upper portion of younger unfertilized flowers which point upwards, and a lower portion of downwardly pointing flowers which have been fertilized. The calyx and corolla turn brown and cover the developing fruit.

The calyx tube is about half the length of the corolla, with five almost equal teeth (Fig. 5, p. 11). The standard petal is comparatively large and broad. The wing and keel-petals adhere to each other at one point as they become older, and their claws are fused to the stalk of the stamens for about one-third of their length. The ovary contains numerous ovules: usually only 2 or 3 seeds develop. The pod splits open along one side to release the seeds.

White clover is practically self-sterile, but contains more plants capable of producing seed on being artificially self-pollinated than does red clover. Hive bees are the usual pollinating agents. The diploid number of chromosomes is given by Karpechenko and Wexelsen as 32, and by Bleier as 28.

Seed and Seedling. The seed is heart-shaped, pale yellow or pale brown in colour. As it gets older the seed loses its bright colour and becomes a dull reddish brown. It is very similar in size and shape to alsike clover (Fig. 34) but is slightly smaller. Samples of the wild type may contain 25 per cent or more of hard seeds. Very common impurities in white clover seed are Yellow Suckling Clover (see p. 38), which may be present to the extent of 50 per cent, Birdsfoot Trefoil (p. 65), Trefoil (p. 57), Wild Geraniums (*Geranium molle* and

G. pusillum), Sheeps' Sorrel (*Rumex acetosella*) and Field Madder (*Sherardia arvensis*).

The seedling of the wild type of white clover has small oval cotyledons about 3 mm. long by 2 mm. broad, situated on stalks about half as long as the cotyledon. The first leaf is almost circular, with a slightly toothed margin. The mid-rib of this leaf is distinct, but the other veins cannot be easily seen from the upper surface. The whole seedling is devoid of hairs (Fig. 12A, p. 46).

Cultivated Types. White clover exists in a number of different forms, of which the following are the most important:

1. Ladino, Giant, or Mammoth White Clover (race *giganteum*).
2. Dutch White or Ordinary White Clover (race *hollandicum*).
3. Wild White Clover (var. *sylvestre*).
4. New Zealand White Clover.

1. LADINO, LODI, OR GIANT WHITE CLOVER is a cultivated form which comes from Lombardy. It has exactly the same structure as the other white clovers, but grows to an immense size under suitable conditions. It is known as a *gigas* mutation, but has the same number of chromosomes as the other forms. Despite the size of this "mammoth" white clover it is of little use in this country, since it cannot stand the winter.

2. ORDINARY OR CULTIVATED WHITE CLOVER is often called Dutch Clover because it was first grown as a seed crop in Holland. It is also known as Honeysuckle Clover. It was introduced into England during the seventeenth century. It is intermediate in size between Lodi clover and wild white clover, but it is not a cultivated form of the latter. It is a short-lived plant, with fewer runners, which do not root so plentifully as the wild type.

It starts to grow earlier in spring: it also flowers earlier, and continues growth later.

Seed comes from Holland, Russia, Central Europe and America. A small amount is grown in Essex.

Dutch white clover is suitable for short leys only, as it dies out in five years at the most. It adds more to the hay, and its seed is cheaper than wild white clover, but since the virtues of the wild type have become better known, the cultivation of Dutch white clover has diminished.

3. WILD WHITE CLOVER, which is indigenous or native to this country, is a truly perennial form, and is now recognized as one of the most important plants available to the farmer. It is not always easy to distinguish with certainty between individual plants of wild white clover and cultivated white clover. The wild plant has more nodes, and much shorter internodes than the cultivated type, and roots at every node. It flowers later and has fewer flower-heads. The leaves and their stalks are finer. Its seeds on the whole are smaller. It is not possible to distinguish between the types by the cyanophoric test (p. 30) since it has been found that both cultivated and wild forms include cyanophoric and a-cyanophoric individuals.

Wild white clover possesses many valuable attributes. It grows rapidly from seed and soon mats the grasses into a dense turf. It stands up to grazing extremely well, is very palatable, nutritious, and especially rich in calcium, an element indispensable for bone and milk formation. It is very adaptable to different soils and climates, stands up to drought, and suffers little from fungus and insect pests. It lasts for many years and builds up a great deal of fertility in the soil.

On the other hand wild white clover starts growth in spring much later than some of the valuable grasses like

perennial rye-grass and cocksfoot, and it gives very little keep during the winter. It is a summer and autumn grazing plant, and should not be allowed to develop to excess. Close grazing of a mixed sward in the spring, just as the grasses are coming into vigorous growth, weakens these and allows wild white clover to extend. On the other hand, if the grasses are allowed to grow long, they shade the clover and cause it to diminish.

Wild white clover, despite its tap-root, is largely a surface feeder. Generally speaking, it does best on the heavier soils, but it will also thrive on light soils if the rainfall is adequate. It responds in a remarkable manner to applications of phosphatic manures, particularly basic slag. On poor pastures a heavy dressing of 10 cwt. per acre has been found more beneficial than smaller dressings at short intervals.

There is little advantage in sowing more than one pound of wild white clover seed in a seeds mixture. As little as one-quarter of a pound often gives good results when combined with proper manuring and management.

4. New Zealand White Clover. New Zealand exports white clover seed under two categories, "Mother" seed and "Permanent Pasture" seed. New Zealand White Clover Certified Mother Seed comes from a regional strain of great persistence and winter growth, with an abundant, dense and leafy foliage. These plants, although to the expert eye quite different from English Wild White Clover, are superior to the Dutch white clovers on account of their early, rapid growth and their persistence for at least three years. They are not as valuable as indigenous wild white clover, but the seed is cheaper. New Zealand White Clover Certified Permanent Pasture Seed has no special advantages so far as this country is concerned.

Seed Production. There are numerous local strains of wild white clover, which, although definitely wild white clover, yet differ remarkably in their rapidity of growth, luxuriance and so forth. Some of these strains are more valuable than others. Kentish Wild White Clover, for example, harvested from very old Weald pastures, has for many years enjoyed a very high reputation. During the war as much as thirty-five shillings per pound was paid for genuine seed. Cotswold Wild White Clover is also well known.

Under the Wild White Clover Certification Scheme, promoted jointly by the Ministry of Agriculture and the National Farmers' Union, the production of wild white clover seed is being encouraged in all parts of the country. Two grades of seed are recognized. Grade "A" certificates are issued for seed from genuine old pastures which have been under grass for more than ten years: Grade "B" certificates for seed from crops of once-grown indigenous wild white clover. That is, Grade B seed is the produce of plants which were seeded down from genuine wild white clover seed less than 10 years ago.

Before a pasture can be "approved" for wild white clover seed production its history must be made known to inspectors, who examine the herbage and conduct a growing-on trial with some of the seed. Up to the end of 1935 some 6,700 acres of Grade A pasture and 2,100 acres of Grade B pasture had been approved.

In the harvesting of wild white clover seed in Kent, the pastures are bared down with sheep until the end of May. Mowing is carried out with an ordinary mower. Sometimes a sack is tied to the cutter bar and allowed to drag on the ground: the cut heads are raked off at intervals by a man walking behind the machine. It is stated that over-ripeness of the heads leads to a high proportion of "hard" seeds.

Old pasture should not be seeded oftener than once in

every 2 years. The yield is very variable, from 30–100 lb. per acre. Double these amounts may be obtained from once-grown seed. From this, in Kent, is cleaned out indigenous perennial rye-grass seed and a small proportion of birdsfoot trefoil seed.

It is not an easy matter to distinguish between the seed of Dutch white clover and wild white clover: there is no single feature which makes this possible. Wild white clover seed is slightly smaller than Dutch white, having on the average 1,900 seeds to the gramme: against about 1,500 in the case of Dutch white. The seeds of wild white clover have a less definite groove between the radicle and cotyledons, and are more rounded in outline. True wild white clover contains such characteristic impurities as yellow suckling clover, birdsfoot trefoil, crested dogstail, self-heal, Bent grass and Yorkshire fog.

The Cyanophoric Test. It has been known since 1912 that wild white clover contains a cyanogenetic glucoside and its attendant enzyme. If a seedling or a leaf be crushed and anæsthetized, the glucoside and enzyme react to produce hydrocyanic acid gas. This reaction can be demonstrated by the fact that yellow sodium picrate is turned red by the cyanide.

The test is usually made with picrate paper, prepared as follows: dissolve 1 gramme of picric acid and 10 grammes of sodium carbonate in 200 c.c. of water; soak strips of filter paper in this solution, drain and dry until just moist. The strips can be stored indefinitely in a stoppered bottle.

To make the test, place a seedling or leaf in a narrow tube (tubes approximately 2 inches long by ½ inch diameter are convenient) with a strip of picrate paper, add a drop or two of chloroform or toluene, and tightly close the tube with, preferably, a rubber bung. Incubate on a radiator, or in a convenient pocket. If cyanide

is present the paper should turn red in about half an hour.

Plants which give this colour reaction are said to be cyanophoric; those that do not are a-cyanophoric.

White clover contains both cyanophoric and a-cyanophoric individuals. *Generally speaking*, wild white clover is cyanophoric and ordinary Dutch white clover is a-cyanophoric. The cyanophoric test is used as one of a series of tests to distinguish between seeds of ordinary white clover and wild white clover. If a sample purporting to be genuine wild white clover fails to respond to the cyanophoric test, it is regarded with suspicion. But, on the other hand, if a sample of white clover seed proves to be cyanophoric, this is not necessarily a proof that the sample is wild white clover.

In other words, the cyanophoric test, whilst not in itself absolutely convincing, provides useful data to strengthen or weaken conclusions arrived at from other observations.

Chemical Composition. The Kellner-Fingerling figures for the percentage composition of the white clover plant are as follows (digestible nutrients in brackets).

	Dry Matter	Crude Protein	Crude Fat	N-free Extract	Crude Fibre
Green (beginning of flowering)	18·5	4·4 (2·8)	0·8 (0·5)	6·9 (4·7)	4·8 (2·6)
Hay (beginning of flowering)	84·0	14·9 (8·5)	3·6 (2·1)	35·7 (25·0)	23·1 (11·8)

According to Williams and Evans the protein content of white clover reaches its highest peak in the spring, and gradually decreases to a minimum in July and August.

They give the silica-free ash as amounting to 9·06 per cent of the dry matter on an average. The lime content is 2·927 per cent, and the phosphoric acid 0·616 per cent of the dry matter during the first harvest year. White clover was found to have 269 per cent more lime (CaO) than Italian rye-grass, and more than twice as much crude protein.

CHAPTER III

TRUE CLOVERS (*continued*)

CRIMSON CLOVER OR TRIFOLIUM

(*Trifolium incarnatum* L.)

General Characters. Trifolium, Crimson Clover or Italian Clover is an annual plant. The root is a slender tap-root with fine branches. The nodules on the main root are elongated and closely attached to it. The stem is erect, about 1–2 feet high, slender, unbranched and very hairy: there may be a few purplish blotches on it. The leaves are on long stalks, which get shorter towards the top of the stem. The leaflets are very broad, with entire margins, hairy on both surfaces: the mid-rib is very prominent on the under-side of the leaf. The stipules are membranous, and remarkable because the free portion is usually blunt and broad, often, but by no means always, fringed with purple. Frequently the free portion is green, with a wavy margin, and occasionally it is actually broadly pointed (Fig. 8).

The flower-head is terminal, some distance from the uppermost leaf: at first it is short and spindle-shaped, but later it elongates into a cone about 2 inches long. The flowers are deep crimson. The calyx has 5 long, narrow, hairy teeth almost as long as the wing-petals. The petals drop off after flowering, leaving the one-seeded pod deeply buried in the calyx tube. Cross fertilization through the agency of bees is usual, but the flower can be caused to set seed easily if artificially self-pollinated.

Seed and Seedling. The seed is plump and oval, without a pronounced radicle: it is polished, shiny, chestnut brown, larger than red clover seed: common dimensions are 2·5 mm. long by about 2 mm. wide (Fig. 34, p. 112).

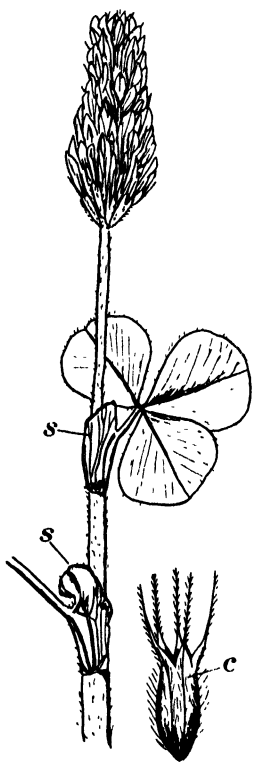

FIG. 8.—Crimson Clover or Trifolium.
s, stipule; *c*, calyx.

The seedling is the largest of the true clovers except subterranean clover. The rounded cotyledons are 7·5 mm. long by 6 mm. broad, on stalks 3·5 mm. long. The first leaf is hairy, rounded, broader than long, being 7·5 mm. by 10 mm. broad, with well-marked lobes at the stalk end. The margin is angular and the veins are distinct. The stipules are broad, tapering to a blunt apex (Fig. 12E, p. 46).

History and Uses. It is probable that trifolium is not a native plant: a closely related, but smaller, species *T. Molinerii*, *Balb.*, which has whitish flowers and hairs lying close to the stem, is found growing wild in Cornwall.

Trifolium is known to have been cultivated in Germany as far back as 1796, and was introduced into U.S.A. in 1818. It seems likely that it was cultivated in Southern France and Switzerland earlier than this.

There are three varieties, namely early, medium and late varieties, indistinguishable from one another by vegetative characters; and also a late variety having white flowers and white seeds.

Trifolium is not a very hardy plant and its use is

confined chiefly to the southern and south-eastern districts of the country. To succeed it must be sown not later than the third week in September, otherwise it does not develop sufficiently to stand the winter. It is immune to clover "sickness."

It is usually grown as a catch crop after a cereal and only the simplest of cultivations is needed. The land is harrowed with a spring-tooth or disc-harrow, the seed broadcast, and rolled down. Elaborate cultivations are unnecessary and undesirable, since the plant likes a firm seed bed.

The usual rate of seeding is from 20–24 lb. per acre when sown alone, or 10–12 lb. trifolium with 14 lb. Italian rye-grass. On foul land the inclusion of 6–10 lb. white mustard seed has been recommended with the idea of keeping down the weeds until the trifolium has established itself.

If a very thick plant of pure trifolium is obtained there is a danger of rotting taking place at the base of the stem before it can be cut for hay.

Trifolium is not usually manured, but bigger crops can be obtained with fertilizers than without. The application of 3 cwt. super, 3 cwt. kainit and $\frac{1}{2}$–$\frac{3}{4}$ cwt. sulphate of ammonia at time of sowing has been recommended as a suitable dressing.

It is usual to feed-off trifolium in May or June with hurdled sheep. It may also be cut and "soiled" to dairy cows. It is necessary to do this before the plants are in full flower, because the developed flowers are extremely hairy and liable to cause digestive troubles, especially in young animals. Hay from over-ripe trifolium may cause the same trouble.

Trifolium will shoot again after grazing, but if the first growth has been closely folded the second growth is rather dirty and is refused by stock other than pigs. Lambs make rapid progress on trifolium.

Trifolium hay is fibrous and not of good quality, and it is best fed mixed with clover or meadow hay. It is difficult to make properly and very liable to develop mildew if it becomes at all damp.

Seed Production. Seed crops are taken chiefly in Essex, especially between Dunmoy and Bury St. Edmunds, but in Suffolk and other counties seed is also saved. Sometimes, in order to provide the seedlings with shade and to prevent drying-out during the early stages, seed is sown in the standing corn before harvest. A "fiddle" is used and little damage is caused to the wheat. Usually trifolium is sown by drill as soon as possible after the straw crop has been removed. About 24 lb. of seed are sown.

On the damper land in Suffolk slugs are often a great nuisance, especially if the seed is sown late.

The seed crop is ripe when the "cob"—that is the persistent calyces with the enclosed seed (Fig. 8, p. 34)—comes away easily when the stalk is pulled through the closed hand. This is usually about the middle of July. A seed crop of trifolium is easily damaged and the greatest care has to be exercised in harvesting it. It is best cut early in the morning when the dew is upon it, as this makes the ripe flowers less liable to break away. It is best left out from 3 to 5 days, being turned once carefully, and then threshed straight away. The seed is liable to lose colour in the stack, whilst considerable wastage results from the extra handling involved.

The average yield of seed is about 600 lb. per acre.

Chemical Composition. The green foliage of trifolium at time of flowering contains, according to Kellner-Fingerling (per cent): Dry matter 18·5; crude protein 2·8 (2·1); crude fat 0·7 (0·5); N-free extract 6·9 (5·2); crude fibre 6·2 (3·5). Trifolium hay, cut at the same time, contains dry matter 83·8; crude protein 12·4 (8·4);

crude fat 2·7 (1·2); N-free extract 33·5 (21·8); crude fibre 27·4 (12·9). (Figures in brackets refer to the digestible nutrients.)

YELLOW SUCKLING CLOVER

(*Trifolium dubium* Sibth. = *T. minus* Sm.)

General Characters. Yellow Suckling Clover is an annual plant with very slender stems, which are prostrate when growing in open situations, and more or less erect when growing in competition with tall plants. There is no definite tap-root, but a mass of fibrous roots spreads through the surface layers of the soil. The nodules are spherical, the largest about 2 mm. in diameter. The stems are wiry, up to 18 inches in length, and often turn red as they become older, so that the name Red Suckling Clover is sometimes applied to the plant.

The leaves are small, narrow, and broadest at the apex. The margin close to the apex is notched or toothed, but there is never the projecting mid-rib so characteristic of Yellow Trefoil (*Medicago lupulina*), with which yellow suckling clover is frequently confused (Fig. 9). The common leaf-stalk is short, and the terminal leaflet is separated from the others by a stalk which is much longer than the lateral stalks. The veins are numerous, running parallel at an angle from the mid-rib. There are a few scattered hairs on the under-side of the mid-rib. The stipules are small and sharply pointed, with entire margins: they are not toothed as in yellow trefoil.

The flower-heads are carried at the end of very long slender axillary stalks. There are from 12 to 20, usually 12, small yellow flowers in the head: at first these are erect but they become reversed after flowering. The corolla turns brown after seed has formed, and together with the calyx covers the small, one-seeded pod.

Seed and Seedling. The seed is oval, similar in shape to that of trifolium, but is very much smaller, smaller, in fact, than white clover seed (Fig. 34, p. 112). It is rather less than 1·5 mm. long by about 1·0 mm. broad. It is very shiny and varies from a yellow to olive

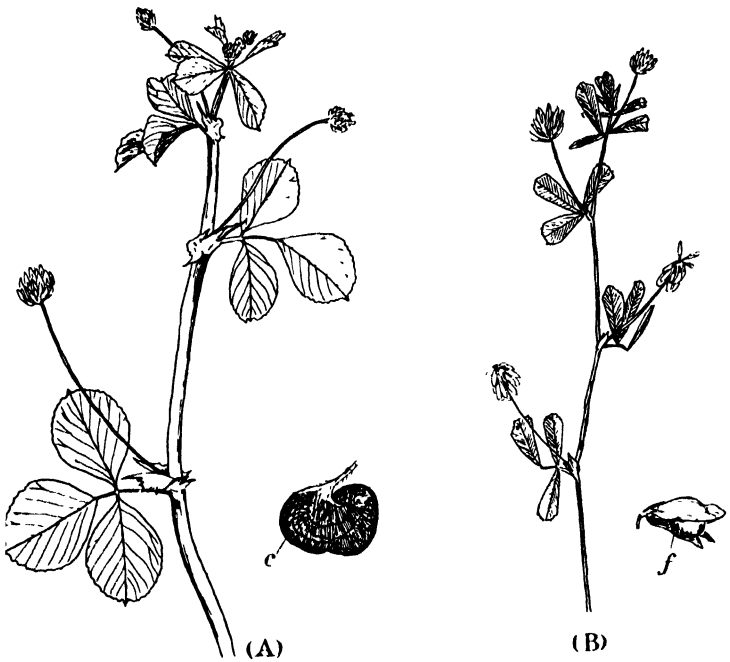

FIG. 9.—Yellow Trefoil and Yellow Suckling Clover.

A, Yellow trefoil: *c*, "cosh" or fruit; B, Yellow Suckling clover plant: *f*, fruit. Note particularly the projecting mid-rib of the trefoil leaf.

yellow in colour. It is said to have remarkable powers of germination and establishment under dry and arid conditions, which make it useful in East Anglia.

The seedling is characterized by the long slender stalks to the cotyledons. The latter are about 3·5 mm. long by 2 mm. broad, on stalks 3 mm. long. The first leaf is 4 mm. long by 4·5 mm. broad at its widest, which

is about a quarter of the distance from the base. The leaf is free from hairs and the veins are distinct on the upper surface (Fig. 12c, p. 46).

Uses. Yellow suckling clover is a native of thin, dry, gravelly soils, and gives a very scanty yield compared with other cultivated clovers. It is annual in habit, but seeds itself so freely that in effect it behaves like a perennial plant. On fertile land it is not worth consideration, but on poor light land it may be usefully employed. Oldershaw has successfully used a seeds mixture containing 2 lb. of yellow suckling clover seed in his amelioration of poor light land in Suffolk. It may also be used for patching up thin areas in a seeds ley, as it grows rapidly from seed.

Cases are known in which Suckling Clover seed imported from the Continent has proved to be *T. procumbens*, not *T. minus*; *T. procumbens* is inferior to *T. minus*, and it has been suggested that the poor results which often follow from the inclusion of "suckling clover" may be due to this substitution.

Seed Production. A small amount of seed is harvested in Suffolk. The seed is sown on clean land in autumn, either immediately after harvest, or actually in a standing crop of late barley before harvest: ¼ of a peck of seed per acre is the usual rate. As in the case of trifolium a firm seed-bed is essential. The crop is ready at the end of July and is cut with an ordinary mower. It is very liable to heat in the stack, because the thin wiry stalk appears to be dry before it is in fact properly cured, with the consequence that it is liable to be stacked too soon. The stacks are therefore made narrow and are ventilated by placing faggots of sticks horizontally at intervals across the ricks.

The yield of seed is from 4–5 bushels per acre.

Yellow suckling clover seed frequently occurs as an impurity in wild white clover seed: some growers of the

latter in Kent actually go over their pastures, spudding out plants of suckling clover to diminish the chances of contamination. At the same time, suckling clover seed separated out from Kentish Wild White Clover has a special value owing to the fact that it is never free from the wild white clover seed.

The Seeds Act of 1920 stipulates that where a sample of alsike, white clover, or wild white clover contains more than 2 per cent by weight of yellow suckling clover, and its associated species, Hop Clover (*T. procumbens* L.), *T. parviflorum* Ehrn., *T. angulatum* Waldst., and *T. glomeratum* L., the exact percentage of these "impurities" must be stated.

SUBTERRANEAN CLOVER

(*Trifolium subterraneum* L.)

General Characters. This plant gets its name from the habit it has of burying its fruit and seeds in the ground. Because of this, subterranean clover behaves like a perennial plant, though it is actually an annual.

The root is a tap-root with numerous branches. The nodules are cylindrical, rather irregular or lobed at times, usually attached by the longer side.

The stems are thick and prostrate, but do not root at the nodes like those of white clover. Cultivated types have stems which may exceed 2 feet in length, radiating from the root stock. Some stems may reach a length of even 6 feet. The internodes are long and hairy. Each plant is capable of forming dense mats of vegetation from 2–6 feet in diameter.

The leaves are on long stalks which often lie close to the stem before curving upwards. The leaflets are broad, rather like those of trifolium. They have entire margins and are hairy; usually there is a triangular patch of lighter green on the upper surface of the leaflet, not

extending to the margin. There may be purplish areas along the veins. At the base is often a purplish area. The stipules are broad, pointed, and stand well away from the stem (Fig. 10).

The flowers are carried at the ends of long axillary stalks, which at first are more or less erect. There are from 2 to 5 flowers, usually 4, in a loose head. These are large in proportion to the plant, and white. The calyx is green at the base, purplish next the teeth, which

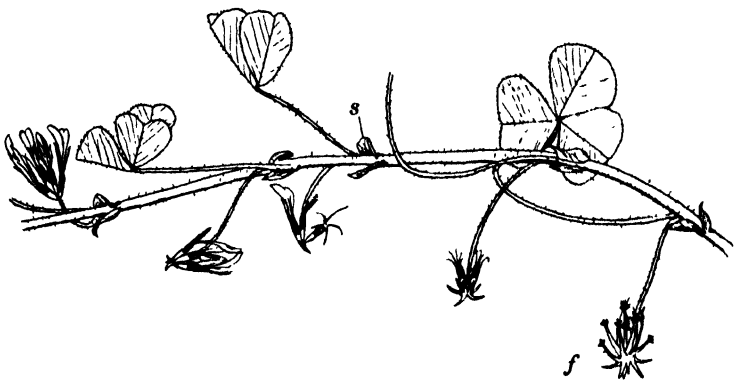

FIG. 10.—Part of a prostrate stem of Subterranean clover.

The youngest flowers are on the left; to the right of these are shown successive stages in the reversal of the flowers and the development of anchoring fibres. *f*, fibres; *s*, stipule. For full explanation see text.

are very long, slender and hairy. The standard is twice as long as the calyx teeth, with a very long claw. The flowers are always self-fertilized.

After fertilization the common flower-stalk turns downward towards the ground. Each flower then reverses itself so that the calyx teeth point upwards (Fig. 10) and the whole head is thrust into the soil. Short thick fibres, each ending in a tiny, five-pointed star, now develop from the flower-head and anchor the fruits firmly below ground, at the same time surrounding and protecting them. These fibres are really the undeveloped calyces of the barren upper flowers.

Each pod, which is a network of fibres, contains one seed: the so-called "burr" consists of several ripe flowers enclosed in the anchoring fibres, and contains from 1 to 3 seeds.

Seed and Seedling. The seed is about 3·5 mm. across, and is almost spherical, with a large hilum (Fig. 34, p. 112). It is dark-purple to black in colour, dull or slightly shining on the surface. It is very liable to contain hard seeds. Seed in the burr may be 80 per cent hard, whilst de-hulled seed has on an average 20 per cent hard seeds.

The seedling is large compared with other cultivated clovers. The cotyledons are 11 mm. long by 7 mm. broad, and taper slightly towards the base. They are carried on long stalks, 15 mm. in length, and at the junction of stalk and cotyledon there is a distinct joint. The cotyledon stalks are usually carried almost vertically. The first leaf is 9 mm. long and 12 mm. broad at its widest. The base of the leaf is almost straight. The veins are distinct on the upper surface, and the leaf is hairy on both surfaces. The stipules of the first leaf are large, broad, and sharply pointed (Fig. 12F, p. 46).

History and Uses. Subterranean clover is native to Britain and other European countries, but many of the wild types have short internodes. It was introduced into Australia about 1887–88 as an impurity in agricultural seeds, and during the last 20 years it has been cultivated as a fodder plant. It was made popular by A. W. Howard, of Mount Barker, South Australia, who experimented with the plant for over 30 years until his death in 1930. Owing to its habit of growth it chokes out weeds, and it has even been recommended for sowing on pastures infested with bracken, since stock trample on the young ferns in their anxiety to get at the clover, which itself competes strongly with the weed.

It grows relatively well on hilly, strong and poor

ground, and is palatable to stock: it requires at least 20 inches of rain for successful growth, for if the land becomes dry and hard it is unable to bury its fruits and so re-seed itself. It responds in a remarkable degree to dressings of superphosphate.

Three distinct forms have been described, namely:

1. Early Flowering, with small leaves having white markings, often with red flecks, and much stem.
2. Mid-season, which is more leafy than the above. This is the most popular sort in Australia.
3. Late Flowering. This has no leaf markings, is more vigorous in growth, and flowers about a month later than the mid-season type.

Experiments with subterranean clover have been conducted in various parts of England and Wales, and it is quite certain that the plant will grow well in these islands. Its greatest virtue is the amount of winter keep that it provides compared with that produced in summer. So far, however, it is not possible to say in what circumstances the plant is likely to prove superior to our other clovers, nor how the plant may best be fitted into farm rotations. The cost of the seed prevents its use as an autumn catch crop to provide autumn keep in competition with trifolium and Italian rye-grass.

In order to establish subterranean clover as a permanent plant in grass land Wm. Davies suggests that it would be necessary to remove stock at flowering time so as to permit re-seeding to take place. After the removal of a light hay crop in early July sheep could be turned in, and these would trample in the seeds and so make re-establishment more certain. Careful management of the grazing, combined with the use of superphosphate, is essential if subterranean clover is to succeed.

The seed rates in Australia vary from 1 lb. to 12 lb. per acre, with from 6–8 lb. per acre as an average.

Although the seed is large compared with other

clovers, shallow planting is essential to get good results. Seed should not be covered by more than half an inch of soil.

In Australia the buried seed heads are raked out by hand or horse implements: a yield of 300 lb. of cleaned seed per acre is considered satisfactory.

STRAWBERRY CLOVER

(*Trifolium fragiferum* L.)

General Characters. Strawberry clover is a perennial plant very similar to white clover in all its vegetative parts. The main root is strong and tough, with stout lateral roots arising close to the crown. The nodules are longer than broad and flattened, irregular on the surface. Its stem is prostrate but does not root very freely at the nodes. The leaves are on long, more or less erect stalks, and the leaflets are finely toothed along the margin: a very faint crescent band may be present on the upper surface.

The stipules, however, are relatively much larger than in white clover. They are broad at the base, completely encircling the stem, and then taper to a long-drawn-out point rather like those of alsike clover (Fig. 11). As they grow older they become brownish, thin and papery.

The flower-head is terminal on a long stalk. Immediately below the flowers is an involucre, or collection, of thin papery bracts, which alone is sufficient to distinguish strawberry clover from white clover. The bracts take the form of narrow, dirty-whitish, tapering leaves, united at the base where they join the main flower-stalk (Fig. 11B). The flower-stalks are very short.

The calyx has very narrow teeth, and is extremely hairy on the upper surface with dense, silvery-white hairs. The corolla is pinkish white.

After fertilization the calyx becomes very much in-

flated, thin and papery, with a fine network of veins on the surface. Usually only two of the calyx teeth can now be easily seen. As a result of this dilation the ripe flower-head becomes a spherical ball over an inch in diameter, and being pink in colour, resembles a strawberry. Within the swollen calyx are the remains of the corolla and the fruit. The fruit is a short, rather angular pod containing 1 or 2 seeds. It splits open to release the seeds.

FIG. 11.—Part of a runner of Strawberry clover showing the inflated calyces in the flower-head.
C, single inflated calyx; *f*, fruit; *b*, ring of bracts just below flower-head; *s*, stipule.

The seed has the same general form as that of white clover, but it is considerably bigger (Fig. 34, p. 112): it is about 2 mm. long by 1·5 mm. broad. The colour is reddish brown, or a pale olive-brown, liberally flecked with small dark, almost black, spots or splashes.

History and Uses. Strawberry clover is found growing wild in many parts of the country: it is very common on the marshes of the North Norfolk coast and

in similar situations. Although its use as a pasture plant on partly consolidated sands near the sea coast was suggested by Lawson as long ago as 1852, its real recommendation as an agricultural plant comes from Australia and New Zealand. In these countries it is said to have brought about remarkable improvements

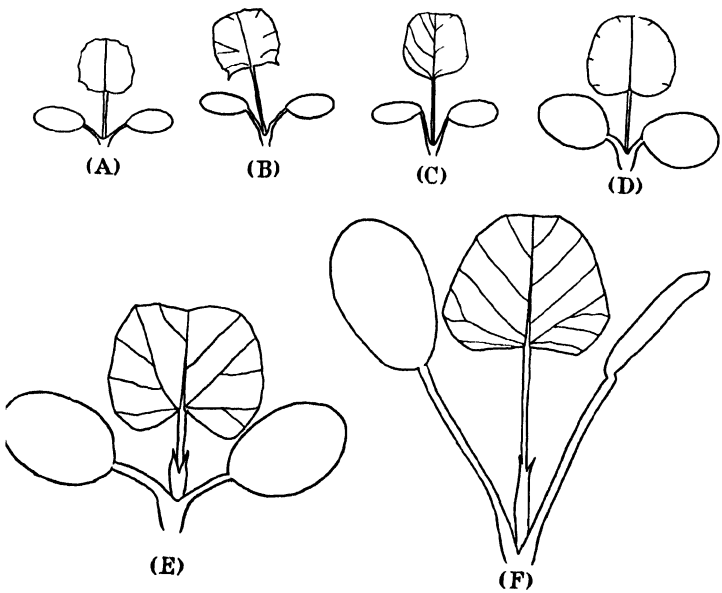

FIG. 12.—Seedlings of the true clovers.

A, wild white clover; B, alsike clover; C, yellow suckling clover; D, red clover; E, crimson clover; F, subterranean clover. All drawn to the same scale, but hairs on D, E, F, not shown.

on heavy swampy ground close to the sea, where formerly only coarse grasses and reeds were to be found.

Few experiments have so far been carried out in this country with strawberry clover, but there is evidence to show that the plant will succeed here on the same sort of land as it does in New Zealand.

Strawberry clover seems to withstand even prolonged flooding by sea water. By mingling with the indigenous

herbage it sweetens the grazing and encourages closer depasturing, which in turn has a beneficial effect upon the sward.

Since it grows in a fashion similar to wild white clover it might be worth while to experiment with a few pounds of seed on pasture land liable to sea flooding. It would be necessary to examine the herbage carefully to find out if the plant were actually thriving, because it is very easy to confuse strawberry clover with the commoner wild white clover.

CHAPTER IV

THE MEDICKS—GENUS *MEDICAGO*

General Characters of the Genus. The Medicks are herbaceous plants which resemble the true clovers in many respects. They are erect plants with trifoliate leaves, and the leaflets alone serve to distinguish members of the two genera. Those of the medicks are always more or less strongly toothed towards the apex, whilst the mid-rib projects as a distinct sharp point. This mucronate apex, as it is called, is never found in the true clovers (compare Figs. 4, p. 10, 6, p. 20, and 7, p. 24, with Figs. 9, p. 38, and 13, p. 50).

The stipules of the medicks are also toothed, whilst those of the clovers have an entire margin.

The flower-heads of the medicks consist of loosely collected flowers. The stamens are always diadelphous. Another important characteristic is the coiled fruit. As soon as fertilization has taken place the ripening pod begins to twist into a spiral. In trefoil, the coiling does not get very far, but in lucerne the pod may be twisted into several coils. The medicks, too, differ from the clovers in that the withered corolla drop off and does not surround the fruit as it does in the clovers. Only two species of medick are cultivated in this country, namely—

1. Lucerne, or Alfalfa (*M. sativa* L.).
2. Black Medick or Yellow Trefoil (*M. lupulina* L.).

LUCERNE

(*Medicago sativa* L.)

General Characters. This perennial plant possesses a very strong tap-root as much as an inch in diameter, penetrating several feet into the ground. Three different types of root system have been found in cultivated lucerne:

1. The ordinary unbranched tap-root system.
2. A tap-root which is branched and bears well-defined underground stems.
3. A branched tap-root with buds and aerial roots.

Hardiness and productivity appear to be correlated with the last two types of root.

From the crown spring numerous stems, reaching a length of 3 feet or more. These stems are formed from buds which develop on the crown or at the base of the older stems, so that mature lucerne plants have a closely tufted appearance. Each stem is erect, rounded or slightly angular, free from hairs, and may branch at the base.

The leaves are trifoliate, on a common stalk shorter than the leaflets. The terminal leaflet is on a longer stalk than the laterals. Each leaflet expands evenly for about three-quarters of its length, and then contracts to the apex. The margin is toothed towards the apex, and the mid-rib projects as a sharp point. The leaflets are free from hairs. The stipules are broad at the base, toothed at the margins, tapering to a fine, toothed point (Fig. 13).

The flower-head, which is a raceme of numerous bluish-purple, occasionally yellow, flowers, is carried on a stiff axillary stalk. At the base of each individual flower-stalk is a narrow bract. The calyx has five teeth as long as, or longer than, the tube. Each wing-petal has a curious backwardly projecting finger-like process at the junction of claw and expanded portion (Fig. 13).

In front of the process, on the outer side of the petal, is a depression: this is actually an extrusion which projects towards the centre of the flower, and engages with a depression on the surface of the corresponding keel-

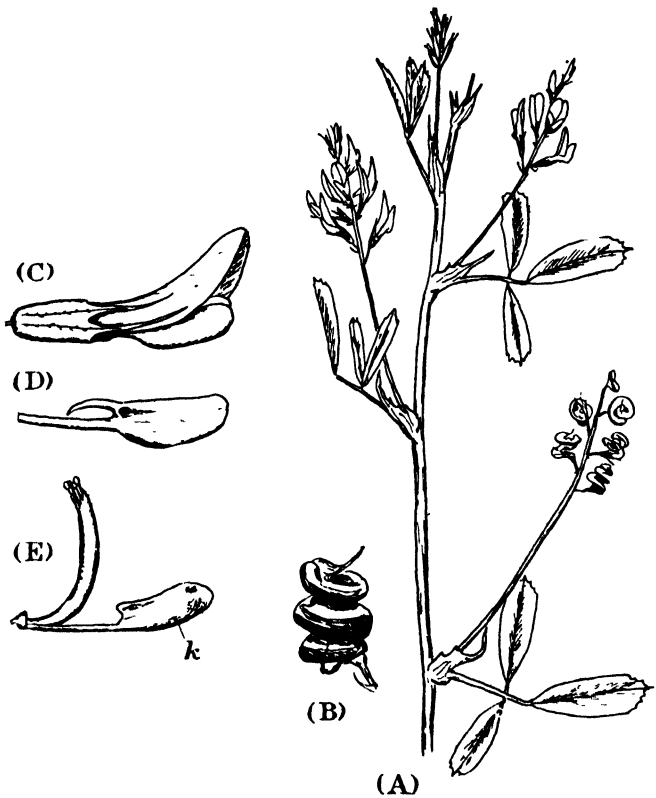

FIG. 13.—Lucerne.

A, part of plant; B, mature, coiled fruit; C, individual flower; D, wing-petal showing the finger process and depression; E, ovary released from the keel-petals and curving upwards; *k*, keel-petal.

petal. The keel-petals are not formed into a beak, but are free and separated at their apices. The stamens are diadelphous. The pistil is composed of a long narrow ovary with a short style and bilobed stigma. The ovary

contains numerous ovules, and curves backwards when released from the petals. Pollination is carried out largely by bumble-bees, and cross-fertilization seems to be more common than self-fertilization. The diploid number of chromosomes is thirty-two.

The fruit is a pod coiled spirally upon itself two or three times, forming distinct loops. It contains several seeds which are released by the splitting of the pod.

Seed and Seedling. The seed is yellow and of an irregular, somewhat angular kidney shape, up to 3 mm. long by 1·5 mm. wide (Fig. 34, p. 112). Many of the seeds, however, are shorter and plumper, approaching almost the shape of red clover seed. When looked at from a point opposite the micropyle the seed appears slightly curved. There is no sharply projecting radicle as in Black Medick.

The seedling has cotyledons about 9 mm. long by 4 mm. broad. These taper slightly towards the stalks which are short, but distinctly longer than those of red clover. The first leaf is carried on a slender stalk several times longer than the blade. The blade is simple and free from hairs: its apex has a distinctly projecting mid-rib and the base tapers away suddenly to the stalk. The veins, with the exception of the mid-rib, are indistinct on the upper surface. The stipule to the first leaf is long and tapering (Fig. 15, p. 58).

The epicotyl, or stem-like portion just above the cotyledons, now elongates, carrying the first leaf with it. Subsequently, the second leaf is produced above the first: it is trifoliate and similar to the permanent leaves already described (Fig. 14). The seedling of lucerne at this stage consequently is long and spindly in contrast to the more usual rosette type of growth found in the clovers and other leguminous plants. Buds now form in the axils of the cotyledons and the lower leaves, giving rise to stems. It is therefore important that lucerne

should be neither grazed nor cut close during its early stages, or these buds may be destroyed.

Owing to this method of growth, and to the fact that at first the plant spends much of its energy developing its root system, lucerne is often disappointing to those

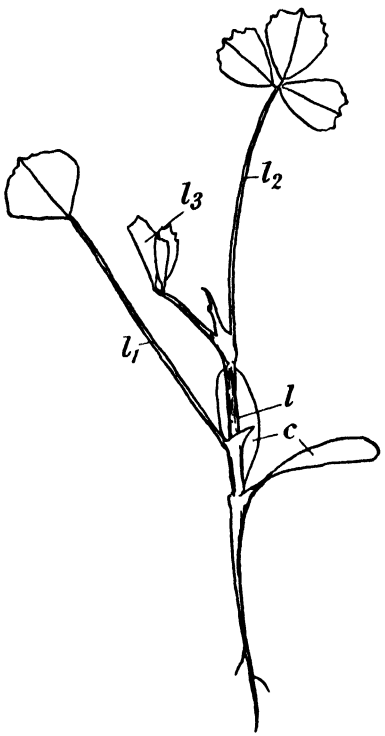

FIG. 14.—Seedling of Lucerne.
c, cotyledons; *l*, epicotyl; l_1, l_2, l_3, first, second and third leaves.

who cultivate it for the first time. But once established it will out-yield any other leguminous forage plant over a series of years.

History and Types. Lucerne is a forage plant of great antiquity, possibly the oldest forage plant in existence. Its other name, Alfalfa, which is commonly

used in the Americas, is derived from a Persian word meaning "the best fodder."

There are two species of lucerne, the Common (*Medicago sativa* L.), and the Sickle (*M. falcata* L.), so called because its pods are curved in the shape of a sickle, not coiled: it has yellow flowers and is extremely hardy. Sickle lucerne is not cultivated in this country, but is of interest because it is supposed to have crossed naturally with common lucerne, to give numerous intermediate types having variegated flowers of all shades, ranging from a light blue to a pale yellow, and less tightly coiled pods than common lucerne. The well-known Grimm lucerne belongs to this class.

Uses. For its successful growth lucerne requires a deep soil, well drained and without a high water table. The soil must not be acid. It does best in a warm dry climate, although it will grow successfully in areas of moderate rainfall provided the weeds can be kept down whilst the plant is establishing itself. It is grown chiefly in the south and south-east of the country, particularly Essex and more recently south-west Norfolk. It is on the lighter soils that it is most popular, because it is less affected by drought than any other perennial forage crop. It is hardy and not seriously affected by frost.

Lucerne does best when grown alone, although it is often sown as one component of seeds mixtures for long duration leys. Drilling in rows from 10–12 inches apart is more satisfactory than broadcasting, since it is possible to work the soil in between the rows with hoe, cultivator or plough during the dead season and so keep down the weeds. This is a most important thing in lucerne culture and success depends largely upon keeping the land clean. On the Norfolk estate where some 2,000 acres of lucerne are being grown for drying purposes, the rows are worked 4 or 5 times during the

winter with a cultivator pushed by a crawler tractor, with conspicuous success so far as weed control is concerned. It is obviously an advantage to start with clean land, and lucerne therefore should follow a crop like potatoes or sugar beet.

For drilling in rows a foot apart approximately 26 lb. of seed are required. Heavier seedings give better results, and as much as 40 lb. per acre have been used to ensure a close stand and keep out weeds. The seed must not be deeply buried, but properly covered with fine soil resting on a well-worked but firm seed bed.

Inoculation of Seed. Since lucerne is not a native plant many fields lack the correct strain of root nodule bacteria, and nodules do not form on the roots. This is a serious disadvantage, for the plant not only does not grow as luxuriantly as it might, but it fails to enrich the soil with nitrogen taken, at no expense, from the air.

To overcome this, inoculation of the seed should be carried out. The older method was to sprinkle dry soil, from a field known to grow lucerne successfully, over lucerne seed previously moistened with a weak solution of cane sugar, or to spread several hundredweight of the soil over the field. Thornton, however, discovered in 1924 that some strains of lucerne nodule organisms are more efficient than others, and these better strains are now available to farmers at a very low price.

Cultures of nodule bacteria are sent out in glass test-tubes plugged with cotton wool. Inside is a "slope" of a jelly-like material, on the surface of which is a whitish slime of bacteria. There is also a small packet of di-acid calcium phosphate. The latter is dissolved in one pint of skim milk. The bacterial slime is scraped off the jelly with a clean stick and stirred up in the milk until thoroughly well mixed. This liquid is then sprinkled over the seeds until each one is covered with a film of moisture. After drying in a dark place—for

sunlight kills bacteria—the seed should be sown as soon as possible.

The cost of inoculating lucerne seed is less than three shillings an acre, and is a wise precaution.

Lucerne can be sown in spring under barley, or on bare ground in late summer. Probably the latter is the more satisfactory method, as it enables weeds to be kept in check right from the start.

Strains. Various strains of lucerne are available, coming from France, Hungary, South Africa, and America. A very small quantity of seed is saved in England: this is often said to be superior to imported strains, but the only large-scale trials of lucerne in this country—those carried out between 1925–36 by the National Institute of Agricultural Botany—gave pride of place to Hungarian seed, with Provence second, and Grimm and English equal thirds.

Towards the end of the year in which the seed is sown it is desirable to run the mower over the crop. This checks the centre shoot, and causes the buds lower down to break and form stems. The following season the ley must not be cut more than twice, or it will be seriously weakened. Subsequently, three cuts per season may be expected, and in very good seasons two more, making five in all.

Lucerne is such a valuable crop that it is usually cut and fed green, or made into silage. It also makes good hay, but requires careful handling, otherwise the leaves, the most valuable part of the plant, may be knocked off and lost. It should be cut just as the first flowers are forming. Lucerne is also being grown in parts of the country for the manufacture of lucerne meal. Young lucerne is cut whilst in vigorous growth, dried, ground into powder, and bagged within the space of 2 to 4 hours. It is used as a concentrated food for mixing with other foodstuffs.

Seed is saved from the second cut. The average yield is about 400 lb. per acre.

Chemical Composition. Woodman, Evans and Norman give the following figures for lucerne:

	Lucerne in Bud	Lucerne in Flower
On basis of dry matter	Per cent	Per cent
Crude fibre	23·9	29·7
Digestible crude protein	15·5	13·0
Digestible organic matter	58·6	53·4
Starch equivalent	50·8	42·4
Digest. coeff. of crude protein	75·8	74·5
„ „ „ N-free extract	74·2	70·2
„ „ „ crude fibre	46·3	42·6
„ „ „ organic matter	65·7	60·4

They state that "lucerne, both in bud and in flower, is distinctly inferior, in respect of digestibility and nutritive value, to pasture grass submitted to systems of cutting at intervals varying from 1–5 weeks."

Nevertheless, lucerne compares very favourably with other leguminous forage crops which are normally cut at about the time of flowering.

YELLOW TREFOIL OR BLACK MEDICK

(*Medicago lupulina* L.)

General Characters. Trefoil, Yellow Trefoil, Hop Clover or Black Medick, is an annual or biennial plant. It has a slender tap-root about a foot long with a few fine branches. The nodules are narrow at the point of attachment, often lobed or divided at the apex, seldom more than 5 mm. long. The stems are erect or semi-prostrate, up to 2 feet long, slightly angular, with numerous short hairs. They may branch freely or

scarcely at all. The leaves are trifoliate, the terminal leaflet having a much longer stalk than the laterals. The leaflets are broadest towards the apex, tapering towards the stalk: the mid-rib projects as a distinct point and the margins are slightly irregular. They are free from hairs. The common foot-stalk of the lower leaves is very long and slender: that of the uppermost leaves is frequently very short (Fig. 9, p. 38).

The stipules are large and broad, toothed and sharply pointed. This, and the mucronate apex to the leaf, serve to distinguish trefoil from yellow suckling clover.

The flower-head is carried at the end of a long slender axillary peduncle. At first it is almost globular, but later elongates: it is composed of numerous, small yellow flowers. These are about 3 mm. long. The calyx is about half as long as the corolla, with five almost equal teeth. The standard entirely conceals the rest of the flower. The free stamen is only half the length of the other stamens. The ovary is hairy and relatively large and stout, with a short thick style and large stigma. It is hairy on the underside. Only one seed is formed in the fruit. After fertilization the ovary becomes curved and turns black: the calyx remains attached to its base, but the corolla drops off. This twisted black fruit, with its slightly raised network, gives the name of Black Medick to the plant (Fig. 9).

Seed and Seedling. The seeds have been aptly described as looking like a pig's kidney (Fig. 34, p. 112), having a definite small sharp point on the concave surface where the radicle projects. The seeds are yellow, shining, plump, and up to 2 mm. long by 1·3 mm. broad.

The seedling has short, broad cotyledons of a rounded oval shape, approximately 7 mm. long by 4 mm. broad, situated on very short stalks. The first leaf is almost oblong, attached to the petiole by its longer side: it

measures about 7 mm. by 11 mm. There is a distinct mucronate projection at the apex, and the margins are faintly toothed. The veins are clearly visible on the upper surface, and both blade and petiole are sparsely

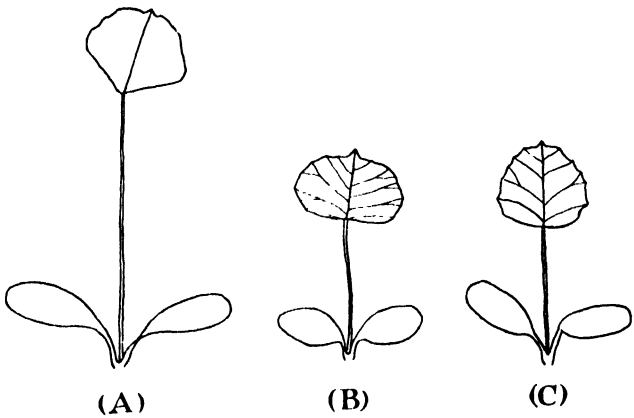

FIG. 15.—Seedlings of A, lucerne; B, yellow trefoil; C, white melilot: all drawn to same scale, but not on same scale as Fig. 12.

hairy (Fig. 15B). There may be a pinkish tinge, especially on the underside. The stipule has a long, fine, tapering point.

Uses. Trefoil has been cultivated in this country since the middle of the fifteenth century; its use did not spread to the Continent for another hundred years. Its use is widespread, but it is possible that the low price at which the seed can be obtained is responsible for this rather than any special merit in the plant itself.

It will grow on most soils, but is most frequently grown on dry light land.

As a hay plant trefoil is not very satisfactory. It is never sown alone on account of its weak stems, and does not mix well with red clover in one-year leys. It flowers earlier than broad red clover, so that to make the most of the trefoil it is necessary to sacrifice the red clover:

if the crop is left till the clover is ready, the trefoil will largely have disappeared.

In parts of Norfolk it is the custom to alternate a trefoil ley with a red clover ley, so that red clover does not occupy the land oftener than once in 8 years: this is to prevent clover "sickness," for trefoil is less susceptible to Sclerotinia disease than red clover. A trefoil mixture is made up of from 10–12 lb. of trefoil, about 5 lb. Italian rye-grass, and 2 lb. each of alsike, white, and yellow suckling clovers.

Even in this country trefoil leys are not much liked, as the herbage is not very palatable; they are regarded as a necessary evil.

Although annual or biennial in habit, trefoil seeds freely and in this way may propagate itself through several seasons. It is often included to the extent of 1 lb. per acre in seed mixtures for two or more years, especially if the soil is light or chalky. It produces an early bite for sheep.

Seed Production. Home-grown seed comes chiefly from Essex and Suffolk. It is sown in April or May in barley, 16 lb. to the acre, in drills 8 inches apart. It is harvested about mid-July of the following year. It gives only one crop of seed and does not yield a previous hay crop.

The crop is ready to cut when the majority of the plants bear black pods half-way up the stems. It is never possible to harvest all the pods, since those at the base ripen long before those at the top of the plant. Shattering is very liable to occur, so cutting is usually carried out either in the morning or late in the afternoon. The crop may be stacked, special precautions being taken against heating, or threshed at once. In threshing the black fruits are detached, but they do not release the yellow seeds, so the general procedure is to sell the trefoil as "blacks" or "trefoil in cosh," leaving the seed

merchant to complete the separation of the seed. The seed keeps better in the cosh than when milled out, and even after 3 years in the cosh is regarded as being quite satisfactory for sowing.

The average yield of seed in the cosh is 8–12 cwt.; 8 cwt. of cosh will give about 5 cwt. of true seed.

The straw when chaffed is a good feed for sheep, and the cosh is sometimes sold as a scratching material for poultry.

Chemical Composition. The percentage composition of green trefoil, cut at the beginning of flowering, is given by Kellner-Fingerling as follows (digestible nutrients in brackets): Dry matter 20; crude protein 3·5 (2·4); crude fat 0·8 (0·4); N-free extract 8·4 (5·9); crude fibre 5·7 (2·8). According to Honcamp, trefoil hay cut at the time of flowering contains (per cent): dry matter 84·0; crude protein 16·9 (10·3); crude fat 3·4 (1·5); N-free extract 32·4 (22·3); crude fibre 24·0 (12·0).

CHAPTER V

OTHER PASTURE PLANTS

BIRDSFOOT TREFOIL—GENUS *LOTUS*, AND KIDNEY VETCH—GENUS *ANTHYLLIS*

THE BIRDSFOOT TREFOILS—GENUS LOTUS

General Characters of the Genus. The Birdsfoot Trefoils are distinguishable by their leaves, flowers and fruits. The leaf consists of 5 leaflets: the terminal leaflet and a pair of lateral leaflets are situated at the top of the common stalk, whilst another pair of leaflets is situated close to the stem, resembling stipules. The inflorescence is an umbel of from 2 to 5 or more yellow flowers carried at the end of a long slender peduncle. The pods are long and cylindrical, and when ripe tend to spread out like the toes of a bird's foot, hence the name given to the genus.

There are four native species:

Common Birdsfoot Trefoil (*L. corniculatus* L.).

Greater or Marsh Birdsfoot Trefoil (*L. major* Scop. sec. Smith = *L. uliginosus* Schkuhr.).

Hispid Birdsfoot Trefoil (*L. hispidus* Desf.).

Slender Birdsfoot Trefoil (*L. angustissimus* L.).

The last two species are of no interest to agriculturalists in this country, though they are grown to some extent in New Zealand. They are both small, procumbent, annual plants with less than 5 flowers in the inflorescence, and they closely resemble each other. The Hispid species has peduncles longer than the leaves,

3 to 4 flowers in the head, and a pod twice as long as the calyx. The Slender species has peduncles shorter than the leaves, only one or two flowers in the head, and a pod six times as long as the calyx.

The Common Birdsfoot Trefoil and Marsh Birdsfoot Trefoil are of slightly more use in British farming, and will require further description.

COMMON BIRDSFOOT TREFOIL

(*Lotus corniculatus* L.)

Birdsfoot trefoil is a perennial plant with a well-developed tap-root, 2 feet or more in length in mature specimens, with numerous lateral branches. It penetrates deeply into the soil and becomes woody with age. The nodules are oval or spherical, often irregular in outline, from 1–4 mm. in diameter.

Numerous stems arise from the crown. These may either lie flat on the surface of the ground or be quite erect, for birdsfoot trefoil is a very variable plant in this respect. They may be from a few inches long to over 2 feet in length. They are rounded at the base, square or angular, and either hollow or filled with pith in the upper parts. They may be entirely free from hairs or covered with short adpressed hairs.

The leaves are alternate, with a terminal leaflet and a pair of opposite leaflets at the apex of the common foot-stalk, and a pair of opposite leaflets at the base resembling stipules (Fig. 16A). Actually the true stipules are microscopic structures situated immediately in front of the petioles of the basal leaflets: it is customary to refer to the basal leaflets as stipules. The leaflets have short stalks which vary very much in size. They are more or less wedge-shaped, the lower ones being distinctly one-sided: the shape is extremely variable. The veins are indistinct. The green parts of the plant

are cyanophoric, but individual plants occur which do not react to the test described on page 30.

The inflorescence is a simple umbel, the flowers arising on short individual stalks from the top of a long

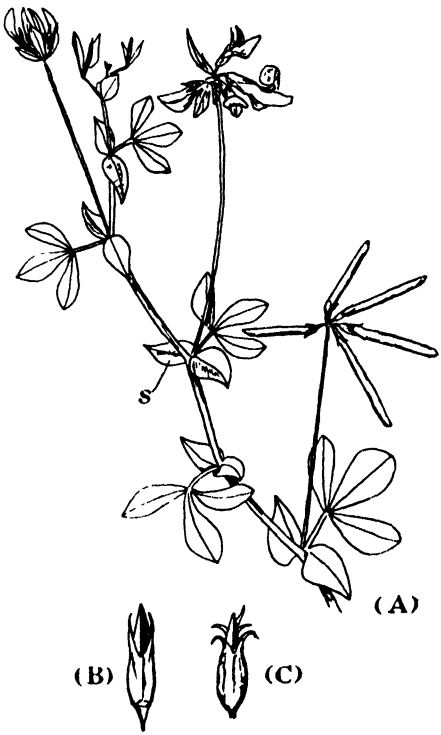

FIG. 16.—A plant of Birdsfoot Trefoil.

s, "stipule," really a basal leaflet; B, bud of *L. corniculatus* showing incurved sepals, C, bud of *L. major* showing star-like, separated sepals.

axillary peduncle several times as long as the leaves. At the apex of the peduncle, just below the flowers, is a leafy bract composed of 3 leaflets. Usually there are 5 flowers, but from 3 to 6 is a common number.

The flowers are yellow, sometimes tinged with red. They turn green when dried. The calyx has 5 teeth:

the upper two teeth converge both in the bud and in the opened flower (Fig. 16B). The standard is usually red at the apex before expanding, and has reddish veins. The wing-petals have a slender claw and a broad expanded portion (Fig. 17A). The keel-petals are shorter than the wing-petals and are fused, forming a narrow tapering cone at their extremities (Fig. 17B). They adhere slightly to the wing-petals and are concealed by

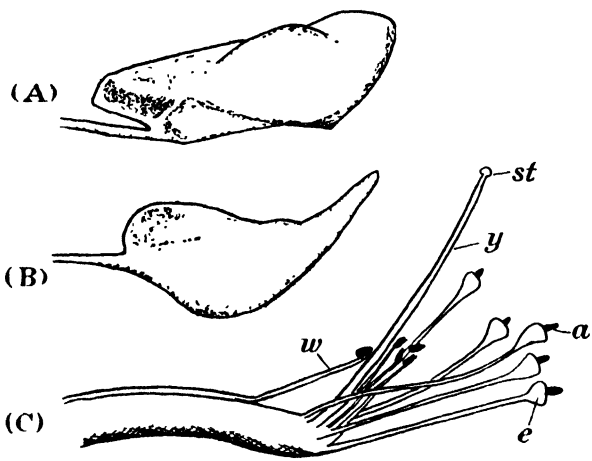

FIG. 17.—Details of the flower of Birdsfoot Trefoil.

A, wing-petal; B, keel-petal, showing tapering cone; C, stamens and pistil; *a*, shrivelled anthers on long filaments; *e*, swollen filament which helps to push pollen out of the tip of the cone shown in B; *w*, shrivelled short stamens; *st*, stigma; *y*, style.

them. The stamens are diadelphous: half the stamens shrivel quickly, whilst the others become dilated and force the pollen into the cone of the keel-petals. The diploid number of chromosomes is 12.

Pollination is affected chiefly by bumble-bees and hive bees, whose weight is sufficient to depress the wing- and keel-petals, thus forcing pollen from the top of the keel as a worm-like pasty mass: some of this adheres to the underside of the insect. The stigma emerges after the pollen. Birdsfoot trefoil is almost completely self-sterile.

The ovary is long, narrow and cylindrical: the style slender, tapering, about as long as the ovary. Up to 40 ovules may be present. The fruit is a long narrow cylindrical pod up to 2 inches or more in length, containing about 20 ripe seeds: it splits open violently into two twisted valves to throw out the seeds.

Seed and Seedling. The seeds are plump and rounded, sometimes almost spherical, at others like a short stumpy seed of red clover (Fig. 34, p. 112). They are bright, shining olive-brown or vandyke-brown, frequently flecked with darker spots. They are from 1·0–1·5 mm. long by 1 mm. broad.

The seedling has a slender radicle with no distinct junction with the hypocotyl. The cotyledons are thick and fleshy, elliptical, about 3 mm. long by 2 mm. broad; the stalks are very short. The epicotyl soon elongates and develops leaves. The first leaf is trifoliate, as is the second (Fig. 18A): the third leaf may have either 1 or 2 basal leaflets, whilst all subsequent ones have the normal 5 leaflets. In the axils of the cotyledons buds develop; these rapidly grow out into stems which branch and form a dense growth.

Cultivated Types. Birdsfoot trefoil is a very variable plant, but three main types may be recognized.

1. The Dwarf Indigenous Type (var. *arvensis* Pers.). This grows naturally in permanent grassland on the lighter types of soil. The leaflets are always relatively broad (Fig. 18B), and the stems more or less prostrate, particularly if there is little competition from neighbouring plants. This type frequently forms a dense circular mat of vegetation. The amount of keep provided is small, but it is palatable and liked by stock: it is purely a grazing plant.

Seed of this type is separated out from perennial ryegrass seed harvested chiefly in Kent; only a small

quantity, probably not more than half a ton, becomes available every year.

2. The Erect, Narrow-Leaved Type (var. *tenuifolius et tenuis* Gaudien = sub-species *tenuifolius* L.). This variety has erect stems, and leaves which are long, narrow and pointed (Fig. 18c). There is considerable variation between the leaves of different plants belonging to this type, and some of them are almost indistinguishable from the erect, broad-leaved type. Even in the same plant,

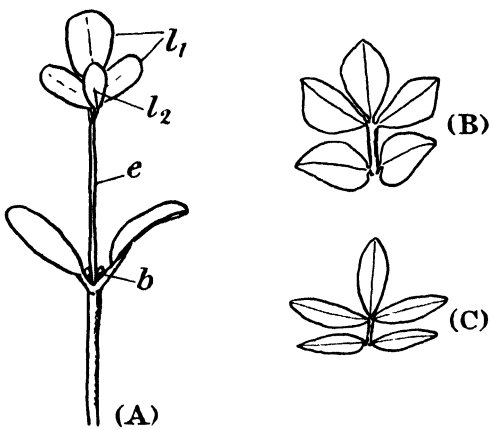

Fig. 18.—A, seedling of birdsfoot trefoil; *b*, buds in axils of cotyledons; *e*, epicotyl; l_1, l_2, first and second leaves. B, leaf of common type; C, leaf of narrow-leaved type.

the first-formed basal leaves may be considerably broader in relation to their length than those higher up the stem. The seedling is much taller and there is a greater distance between the first two or three leaves than in the other types.

3. The Erect, Broad-Leaved Type has the same habit of growth as Type 2, but the leaflets are broader and the herbage is denser. Certain Swiss and Italian strains belong to this type.

Uses. Most foreign commercial seed samples give

rise to plants of the narrow-leaved type. They come chiefly from France, where it is stated that birdsfoot trefoil has been increasingly cultivated since 1920. The plant is even grown alone as a self crop, in areas called "Lotières." From 10–18 lb. of seed are broadcast for this purpose, or 9–12 lb. are drilled in rows 4–8 inches apart. But, generally, birdsfoot trefoil is mixed with grass seeds in order to give the plants more support: typical mixtures are Birdsfoot Trefoil 9 lb., Cocksfoot 7 lb., Perennial Rye-grass 5 lb., or 7 lb. each of Birdsfoot Trefoil, Cocksfoot and Tall Oat grass.

Yields of from 6–15 tons of green fodder from 2 to 3 cuttings have been reported from France: in Denmark the narrow-leaved type has yielded more hay than red clover over two harvest years.

The good points of birdsfoot trefoil are: it will grow satisfactorily on land too poor, too shallow, too impermeable, or too deficient in lime to support red clover or lucerne, and it is not affected by dodder or broomrape. But in this country its use is restricted to the poorer, drier soils, since on the better-class land other leguminous plants greatly outyield it. It must be admitted, however, that very few careful experiments have been carried out to determine the possibilities of birdsfoot trefoil in Great Britain. As a constituent of long duration grassland it may prove very useful in suitable circumstances, and the addition of 1 lb. of seed per acre to the seeds mixture is worth considering. The plant responds well to phosphates and potash.

GREATER BIRDSFOOT TREFOIL

(*Lotus major* Scop.)

This species is very similar indeed to the preceding species, but may be distinguished by the following peculiarities.

The leaves, in general, are larger and broader: the veins, especially on the underside, are conspicuous. The stems are usually longer and somewhat trailing, with loosely spreading hairs. Leaves and stems are definitely not cyanophoric. Distinct underground stems spring from the crown of the plant: they are about as thick as a crow's quill, several inches long, and they root at the nodes.

The flower-head has more flowers, usually 8 to 12, and the flowers are smaller. *L. major* can always be distinguished from *L. corniculatus* when the buds are formed because in *L. major* the teeth of calyx are always more or less curved backwards and outwards, so that they spread out like a star (Fig. 16c): in *L. corniculatus* the teeth of the calyx do not spread out (Fig. 16B).

The fruit of *L. major* is longer and more slender, with more seeds. The seeds are globular or heart-shaped, much smaller than those of *L. corniculatus* (Fig. 34, p. 112). They are usually not more than 1 mm. long, yellow or olive-green in colour. The seedling is very similar to that of common birdsfoot trefoil.

Greater Birdsfoot Trefoil is also known as Marsh Birdsfoot Trefoil, as it is found only where there is plenty of moisture. It is also fond of shade. It is not a very variable plant, though its hairiness is more pronounced in some types than others.

Uses. In this country *L. major* is almost completely neglected as a fodder plant although numerous writers have spoken well of it. In New Zealand it has been found useful in the improvement of marshy or peaty land where other legumes do not thrive. If seed is broadcast over such land the resultant plants grow between the rushes and other undesirable species; stock, seeking out the legume, are encouraged to graze closely and this gradually brings about an improvement in the general herbage. This plan is worth the consideration of the

farmers in this country who have rush-covered land of a similar type.

L. major is also cultivated on newly broken-up moorland in Western Germany.

Seed comes chiefly from Germany and France. In the latter country, seed is known under the name of *L. villosus*.

Chemical Composition. According to Kellner-Fingerling the hay of *L. corniculatus*, time of cutting not specified, contains the following percentages (digestible nutrients in brackets): Dry matter 87·5; crude protein 13·5 (7·4); crude fat 3·0 (1·5); N-free extract 41·7 (27·1); crude fibre 22·0 (11·0).

The ash of the hay, according to Becker, contains 23·3 per cent potash, 20·8 per cent lime, 5·2 per cent magnesia, and 10·9 per cent phosphoric acid.

Ritthausen states that *L. major*, cut immediately before flowering, has the following composition:

	Green (per cent)	Hay (per cent)
Dry matter	23·9	87·3
Nitrogenous matter	5·2	18·8
N-free extract	10·6	39·1
Fibre	6·4	23·4
Ash	1·7	6·0

KIDNEY VETCH

(*Anthyllis vulneria* L.)

General Characters. Kidney Vetch, Sand Clover, or Ladies' Fingers, is a perennial plant in the wild state, but when cultivated behaves more like a biennial. The tap-root is long, with numerous branches bearing spherical nodules about 1·5 mm. in diameter (Fig. 3B, p. 6). From the crown spring numerous leaves which, during the first season at any rate, form a dense rosette close to the surface of the ground. The leaves are either

compound pinnate, with usually 3 or 4 pairs of opposite leaflets and a terminal leaflet, or simple, consisting of a broad, tapering blade on a long stalk. The simple leaves are found usually during the early life of the plant. The leaflets of the compound leaf are long and narrow, with

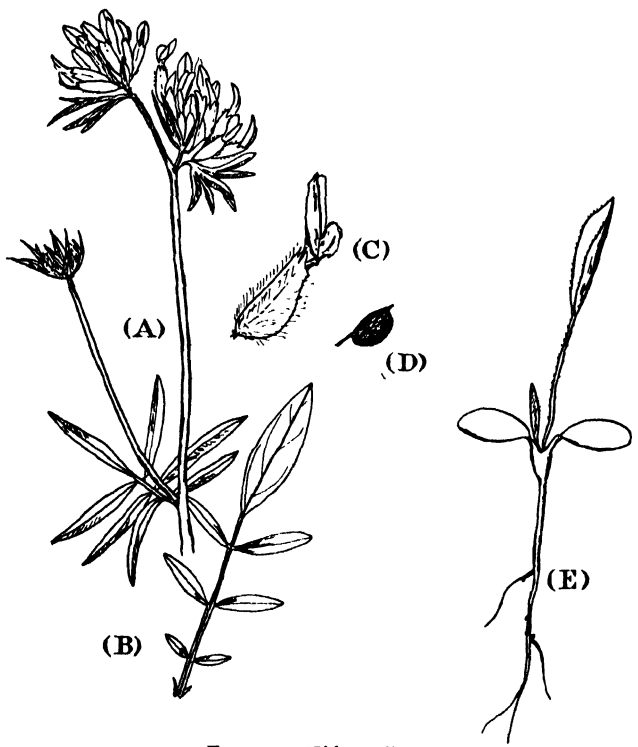

FIG. 19.—Kidney Vetch.

A, upper part of plant showing inflorescences; B, leaf from base of the same plant showing large terminal leaflet; C, flower with inflated calyx; D, fruit; E, seedling.

entire margins. The lower leaves have their leaflets widely separated, giving the leaf a skimpy appearance: the upper leaves have the leaflets crowded together on a much shorter stalk. Frequently the terminal leaflet of the lower leaves is much bigger than the lateral leaflets (Fig. 19B).

The stems are more or less erect, about a foot long, branched or unbranched, cylindrical, and like the leaves clothed with very short silky hairs. They terminate in an inflorescence.

Usually there are 2 inflorescences at the end of the stem, separated by a distinct internode (Fig. 19A). Each flower-head has 2 much-divided bracts beneath it, and contains about 30 yellow flowers closely crowded together. The individual flower-stalks are very short. The calyx is swollen and a very pale whitish-green in colour. It is very hairy. The teeth are short and unequal in length, and form a narrow opening through which the petals emerge (Fig. 19C). The standard is usually yellow, sometimes tinged with red. The wing-petals are firmly fixed to the keel-petals and completely conceal them. All 10 stamens are united into a sheath (monadelphous). The ovary has a long slender stalk, and contains 2 ovules. The style is long and slender, with a sharp elbow-joint about two-thirds of the way from the ovary: it terminates in a globular stigma.

The fruit, usually with one seed, is black, small and rounded, with a fine raised network of veins on the surface. It has a distinct fine stalk (Fig. 19D). The inflated calyx is said to assist in the dissemination of the seed, since the entire flower breaks away from the inflorescence when mature, and is buoyed up when blowing about by the air within the calyx.

Seed and Seedling. The seed is oval and slightly larger than that of red clover, but the radicle is not so prominent (Fig. 34, p. 112). Freshly harvested seed is green at one end and yellow at the other, but these become olive and buff as the seed gets older. It rapidly loses its germination energy.

The cotyledons of the seedling are distinctly larger than those of red clover, with more distinct stalks (Fig. 19E). The first leaf is a simple one, and is broadest

near the apex, tapering towards the base: it is downy and usually more or less folded. Subsequent leaves tend to be simple also, but a number of compound leaves with a few weak lateral leaflets is always produced. A dense rosette of these mixed leaves is formed close to the ground during the first season, whilst flowering stems develop the succeeding year from buds in the crown.

Uses. The cultivation of kidney vetch is of recent date: according to Stebler and Volkart it was begun in Prussia about the middle of last century. There are no distinct commercial varieties, though Schroeter has described three types of kidney vetch according to the colour of the flower, namely those with golden-yellow flowers, those with pale-yellow flecked with purple, and those with deep purple flowers.

Kidney vetch is very hardy and owing to its deep root system stands drought extremely well; and it is therefore chiefly used on the dry thin soils of East Anglia where the rainfall is low. It gives only one cut per season, and the yield is very much smaller than that of red clover; consequently kidney vetch is sown only where the better-class leguminous forage plants are unlikely to succeed. It is much less susceptible to clover rot than the common clovers. It is stated that although of good quality, it takes time for animals to accustom themselves to the rather bitter taste of kidney vetch. When sown alone under barley or oats it is drilled at the rate of from 16–20 lb. per acre, or broadcast at the rate of 30 lb. per acre and fed off by sheep. It may also be cut for hay. The yield of this may be 2 tons per acre. Usually, however, kidney vetch is sown with other plants. Rayns suggests 14 lb. kidney vetch and 6 lb. perennial rye-grass. From 3–4 lb. kidney vetch seed may also be included in seeds mixture for long duration leys.

Some authorities say that it comes best if not sown in a cover crop.

As previously stated, kidney vetch does not behave as a perennial under cultivation. The plants sown soon die out after the first harvest year, and although a certain amount of re-seeding may occur, the yield rapidly diminishes.

Seed Production. When grown for seed kidney vetch must not be grazed or mown during the seeding year: it must be left until late the succeeding summer, when it can be cut and threshed in the same way as red clover. About 200 lb. per acre may be expected. Small amounts are harvested in Suffolk and other of the Eastern Counties, but the chief seed-producing country is France: Germany and Hungary also grow seed.

Chemical Composition. The Kellner-Fingerling figures for the percentage composition of the green plant, time of cutting not specified, are these: dry matter 18 per cent; crude protein 2·4 (1·4); crude fat 0·6 (0·3); N-free extract 8·6 (5·7); crude fibre 5·1 (2·7).

The same authors give these figures for the composition of kidney vetch hay, time of cutting again not stated: dry matter 84 per cent; crude protein 10·2 (6·1); crude fat 2·2 (1·0); N-free extract 36·5 (23·7); crude fibre 29·0 (14·2). Digestible nutrients are shown in brackets.

CHAPTER VI

PLANTS GROWN AS FIELD CROPS

SAINFOIN—GENUS *ONOBRYCHIS*; LUPINS —GENUS *LUPINUS*; MELILOT—GENUS *MELILOTUS*

SAINFOIN

(*Onobrychis sativa* Lam.)

General Characters. Sainfoin, also known as Esparcette and French grass, is a perennial plant with a strong, well-developed root system penetrating deeply into the soil. The upper parts of the root-stock become dark brown and knarled with age. From this spring numerous erect stems 1–2 feet high, bearing leaves and flowers. The stems are round in section, striated, hairy, hollow at the base, solid in the upper regions.

The leaves are on long stalks, and are compound pinnate, consisting of from 5 to 7 or more pairs of opposite leaflets, and a terminal leaflet. The leaflets are narrow and elliptical, with a distinctly projecting mid-rib (Fig. 20). The margin is entire and hairy, as is the mid-rib underneath. The upper surface is free from hairs. The stalks also are hairy. The stipules are broad at the base, tapering rapidly to a sharp point: they turn reddish-brown and papery as they get older.

The inflorescence is axillary, borne upon a very long, slender, often gracefully curving stalk. At first the flowers are crowded together: then the raceme lengthens and they become separated. The calyx has 5 equal

teeth, twice as long as the calyx tube. The 3 lower ones point downwards. The corolla is a handsome rose colour with dark red veins. The standard is rolled back-

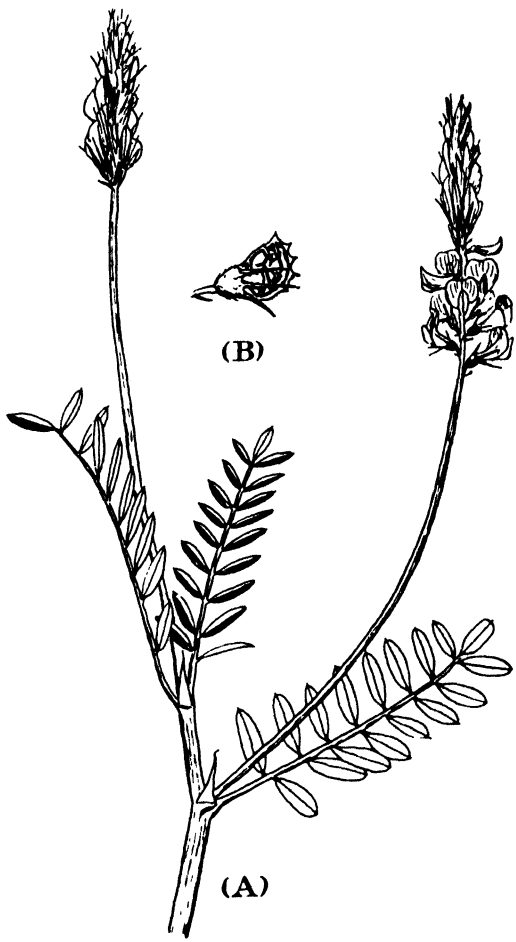

FIG. 20.—Sainfoin.
A, part of plant; B, ripe fruit with calyx attached.

wards; the wing-petals are very short, shorter than the calyx teeth, and entirely hidden by the standard; the keel is relatively very large, as long as the standard. There

are 9 united stamens and 1 free stamen. The ovary is short and rounded, with a very long slender style, and knobbed stigma.

The pod is about twice as long as the calyx, and is very characteristic. The upper edge is nearly straight and the lower one is semi-circular, with short teeth. The surface is covered with a distinctly raised network of veins bearing small teeth. It is brown in colour. It is indehiscent and contains one seed (Fig. 20).

Seed and Seedling. The seed is large and shaped like a small broad-bean seed (Fig. 35, p. 113). It measures

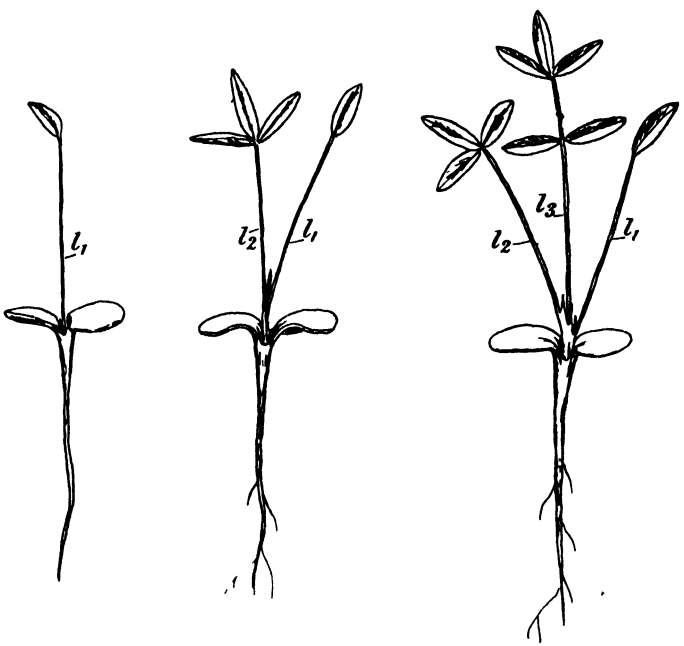

FIG. 21.—Successive stages in the development of a seedling of Sainfoin. l_1, l_2, l_3, first, second and third leaves.

about 4·5 mm. long by 3 mm. broad, and is greenish-brown in colour. Old seeds turn dark brown or black.

The seedling (Fig. 21) has thick, fleshy cotyledons

without stalks. They are almost straight on one side, curved the other. They are much larger than those of red clover, measuring about 11 mm. long by 8 mm. broad. The first leaf is situated on a slender stalk three times as long as the blade, which is narrow and pointed, and at first it is carried at almost a right angle to the stalk. The stipules of this leaf are sharply pointed. The second leaf is trifoliate, with three narrow leaflets. All subsequent leaves are of the compound pinnate type already described. A single stem is first produced, but later numerous other stems form thick dwarf branches on the root stock.

In its early growth sainfoin forms a dense crown on top of the main root, and the base of the leaf-stalks and the stipules is frequently bright red. It does not establish itself rapidly, but after its root system has penetrated deep into the soil it produces a large amount of herbage.

History and Uses. Sainfoin appears to have been cultivated in this country since about the seventeenth century, having been introduced from France and Flanders: it was then referred to as "Saint-foin." A "double-cut" sainfoin was introduced in 1834, and the Giant Sainfoin in the 1850's.

The plant will grow well in many localities provided the soil is not acid, is well drained, and has a low water table. At present the crop is confined chiefly to the dry districts of the chalk and limestone areas in the south and south-east of England, but it is claimed that sainfoin can be grown successfully as far north as the Humber and as far west as the river Severn.

Sainfoin does best when sown alone, although in some counties it is mixed with red clover in seeds prescriptions. It is generally sown with barley as a nurse crop, the sainfoin being drilled at the same time as the barley, but at right-angles to it.

The seed can be sown in the husk or "cosh," in which case from 4–5 bushels are applied with the drill per acre. If milled seed—that is, seed from which the husk has been removed—is used, from 50–60 lb. are required, sown with the seed barrow. Milled seed germinates faster than unmilled seed, and is more free from impurities such as Burnet (p. 79), which always accompanies unmilled seed to the extent of from 2 to 3 per cent by weight.

Sainfoin responds well to applications of farmyard manure, phosphates and potash.

Owing to its habit of growth sainfoin must not be grazed at all heavily during its first autumn, or the "heart" is eaten out of it. It is cut for hay the next year just as the flowers open, and then gives a fodder of extremely good quality, which is rated superior to clover or seeds hay and highly prized for bloodstock.

Varieties. Two varieties are commonly recognized, Common Sainfoin (var. *communis*), and Giant or Double-Cut Sainfoin (var. *bifera*), not distinguishable from their seeds. In fact seed firms do not usually sell sainfoin seed without protecting themselves against claims which may arise through the accidental substitution of one variety for another.

COMMON SAINFOIN is a long-lived plant, capable of cropping well for 7 or more years if kept free from weeds. It does best on the heavier soils. If a small quantity of wild white clover is sown with it the weeds, especially Slender Foxtail (*Alopecurus agrestis*), are held in check. In Suffolk, Field Brome-grass (*Bromus arvenis*), known locally as "bladder grass," is the worst weed of sainfoin leys. Sainfoin takes rather a long time to develop, giving its maximum yield at the third season after sowing. It will give up to 3 tons of hay per acre if well manured and managed, and in addition it grazes well. For hay it is cut when in full bloom. Seed is usually

not saved from common sainfoin until after the third season.

GIANT SAINFOIN, a shorter-lived plant, is sown chiefly as a one-year, but sometimes as a two-year, crop on the lighter soils. It takes the place of clover. It gives about 2 tons of hay per acre, and the second crop, after the removal of the hay, is either grazed by sheep or cut for seed.

Seed Production. Seed is grown chiefly in Essex, Suffolk, Cambridgeshire and Hampshire. English seed is much superior to French seed. Hampshire common sainfoin has a good reputation for longevity, some leys having remained down for over 40 years. In Hampshire it is the custom not to cut for seed until 5 or 6 years after sowing; this ensures that seed is saved only from long-lived plants. When a long ley is ploughed up in Hampshire it is customary not to sow sainfoin again for many years, 15 or more, to avoid "sickness."

The seeds at the base of the flower-stalk mature first and the crop is cut when these are ripe. To avoid loss it is best to cut when the dew is on the plant, as this makes the stalks of the pods less brittle. Losses due to shed seed can be minimized by the use of sheets in the wagons and elsewhere, and by raking the sides of the stacks.

The average yield is about 400 lb. of milled seed per acre.

One of the commonest impurities in samples of Sainfoin seed is the seed of Burnet. Burnet is a plant belonging to the family *Rosaceæ*. There are two species, Lesser Burnet (*Poterium sanguisorba* L.) and Forage or Fodder Burnet (*Poterium polygamum* W. and K. = *P. muricatum* Spach.). Both are very similar except in size, the Forage Burnet being considerably larger in all respects than the Lesser species.

The root stock of the Burnets is stout and perennial, and sends up each year a number of stems a foot or more in height. These are reddish in colour, ribbed, and bear numerous compound leaves. There may be up to 10 or more pairs of opposite leaflets with deeply toothed margins and a terminal leaflet. The stipules are large and toothed (Fig. 22).

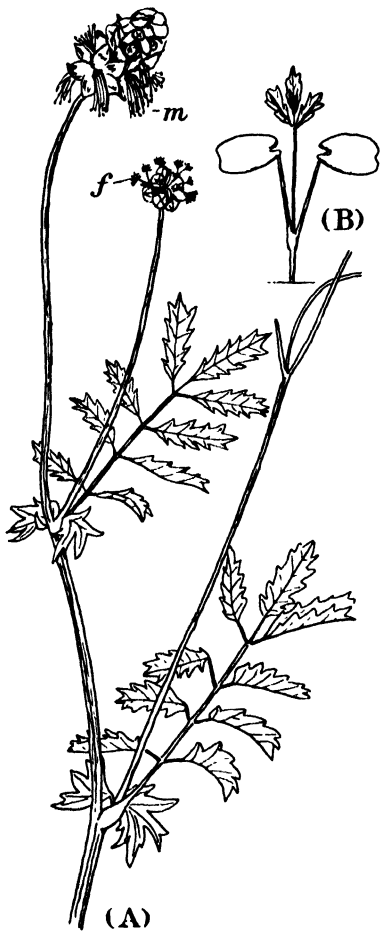

FIG. 22.—Burnet.

A, upper portion of plant; *m*, male flowers; *f*, female flowers. B, seedling of burnet.

The flowers are quite unlike those of the Leguminosæ. They are densely crowded into a more or less spheroidal head at the end of a long peduncle. The flowers have 4 sepals but no petals, and are usually unisexual. The lower flowers are all male, with numerous stamens projecting in hanging tufts: the upper flowers are all female, with usually 2 conspicuous purple stigmas, each situated at the top of a long style. Occasionally bisexual flowers are found.

After fertilization the receptacle becomes quadrangular, with 4 distinct wings, and a coarse irregular network in between (Fig. 35, p. 113). Within the fruit is usually 1, sometimes 2, seeds. The fruit is

brown in colour, intermediate in size between the milled and unmilled seed of sainfoin.

The seedling is easily distinguished from leguminous seedlings by the shape of the cotyledons and the length of their petioles (Fig. 22B). The cotyledon is broadest at the apex, and has a distinct notch where it joins the petiole. The petiole itself is very slender, and much longer than is common amongst leguminous seedlings.

Chemical Composition. Fagan gives the following percentage figures to show the composition of sainfoin when cut as hay just as the flowers were opening (figures based on the dry matter):

Common Sainfoin	Ether Extract	Crude Protein	Fibre	Ash	Soluble Carbo-hydrates	Phosp. Acid	Lime
Stem . .	2·00	9·88	37·50	4·00	46·62	0·376	0·686
Leaf . . .	4·60	21·62	17·20	6·00	50·58	0·516	1·988
Flower-head	3·10	28·67	18·50	6·50	43·23	1·110	1·400
Whole plant	2·61	17·00	28·00	6·25	46·14	0·526	1·260

These figures show that the leaf of sainfoin is much higher in nutritive value than the stem, and in consequence the proportion of stem to leaf in the hay has a very considerable influence on its nutritive value. Fagan analysed both common sainfoin and giant sainfoin at different dates, and concluded that the earlier the hay is cut the more nutritious it is. Delay in cutting results in a greater yield, but a lower quality, for there is a fall in the protein content accompanied by a rise in fibre.

LUPINS—GENUS LUPINUS

Three kinds of Lupins are grown in this country: the Tree Lupin, which is a shrubby decorative plant; the Perennial Lupin, an herbaceous garden plant whose

leaves and stems die down each winter, the strong root-stock sending up fresh growth in the spring; and the Annual Lupin. Only the last is used in agriculture.

Annual lupins are used to a slight extent in this country as a fodder crop, and also for ploughing-in as green manure. Their cultivation is more common on the Continent than here.

General Characters. Lupins can easily be distinguished from other farm plants by their leaves, which

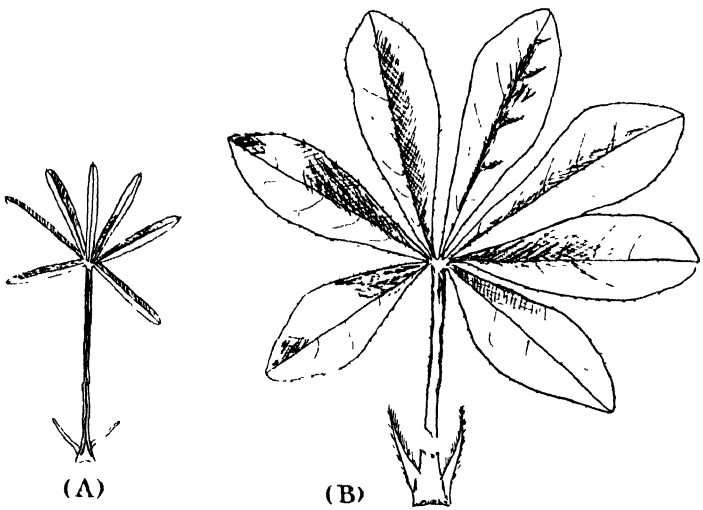

FIG. 23.—Leaf of A, Blue Lupin, B, White Lupin, to show comparative size.

are composed of numerous separate leaflets radiating from the top of a common foot-stalk (Fig. 23). They are palmately compound. The leaf-stalks are long, with slender stipules attached to the base. The stem may be branched or unbranched.

The flowers are borne in loose terminal racemes: they have stout stalks. The calyx often appears to be composed of only two sepals, an upper (or posterior) and a larger lower one. This is caused by the more or less

complete fusion of the two posterior sepals, and the small size of the lateral sepals. The standard has an extremely short, broad claw and the expanded portion is frequently rolled backwards along the central line. The wing-petals have very short claws, and large, very concave expanded portions which totally enclose the keel (Fig. 24). The keel-petals also have short claws: the expanded portions are broad, but taper to a point so as to form a cone similar to that of Birdsfoot Trefoil. The stamens are monadelphous, forming a totally enclosed sheath round the ovary. The ovary is almost cylindrical, slightly curved, with long silky hairs. It encloses several ovules. The style is gracefully curved and tapering, ending in a relatively large stigma. The pod contains several seeds. At first it is soft and hairy: later it becomes dry, hard and brittle (Fig. 24c).

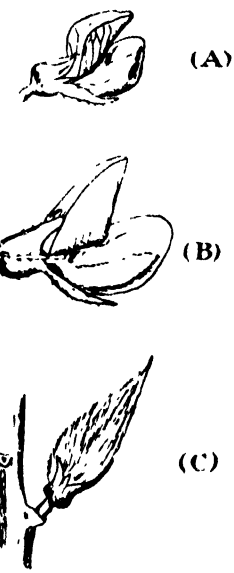

FIG. 24.—A, flower of Blue Lupin; B, flower of White Lupin, same scale; C, young fruit of Blue Lupin.

The root system consists of a strong tap-root with branches. The nodules are strikingly large, often forming irregularly shaped masses on the main and side roots as large in diameter as a sixpence (Fig. 3c, p. 6). The older ones decay about the time that flowering occurs, and turn dark brown.

Cultivated Lupins. There are three species of annual lupin grown on the farm: the White Lupin, Blue Lupin and Yellow Lupin.

THE WHITE LUPIN (*Lupinus albus* L.), often called the Giant White Lupin, is a large plant reaching a height of 6 feet in favourable conditions. The stem is thick

and ribbed, densely covered with fine silky hairs. It is usually unbranched. The leaves have long, strong, hairy stalks. The leaflets are from 7 to 9 in number, broadest about one-third of their length from the apex. The under surface is softly hairy, the upper surface is free from hairs. The stipules are narrow, tapering, fringed with longish white hairs, and dark grey in colour (Fig. 23B).

The flowers are white, often tinged with blue in the early stages, half as large again as those of blue lupin (Fig. 24B). The calyx in some cases appears to have only 2 sepals, a shorter upper one and a long lower one. In other flowers 2 tiny lateral sepals are present. The calyx is densely hairy with short hairs.

The seed is very large, flat and creamy white in colour. It is rather square in outline, with rounded corners (Fig. 35). It may be as much as half an inch across, or even more. The hilum is extremely conspicuous, measuring 3 mm. long by 2 mm. wide. It has a raised margin and a sunken, pinkish centre. The centre of each flat side is usually more or less sunken.

The seedling has a strong tap-root and fleshy hypocotyl. The cotyledons are rather larger than a shilling, almost straight along one side, curved along the other. They are dark green with a yellowish patch near the base. The first leaf has 5 tightly folded hairy leaflets (Fig. 25B).

White lupin is a Mediterranean species and usually does not ripen seed in this country. It is used only for green manuring.

THE BLUE LUPIN (*L. angustifolius* L.), which is the lupin most commonly grown in this country, has a more slender, more rounded, more woody stem reaching a height of about 3 feet. The hairs are numerous, but shorter, giving it a smooth appearance. It branches strongly from the base.

The leaves are altogether smaller. The leaflets are long and narrow, with possibly one more leaflet per leaf than the white lupin. The leaf-stalk is deeply channeled on its upper surface: the stipules are more slender, greener and less hairy (Fig. 23A).

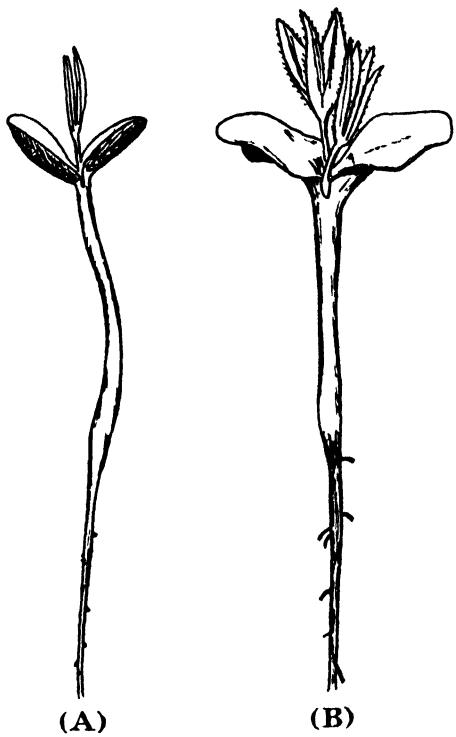

FIG. 25.—Seedling of A, Blue Lupin; B, White Lupin.

The flowers are less numerous, and smaller. The corolla is blue and the calyx is frequently tinged with blue. The upper sepals are broad and short, their tips curving over the top of the corolla tube. The lateral sepals are very small, but the lower one is broad and much longer than the others. The calyx is hairy (Fig. 24A). The diploid number of chromosomes is 40.

The seed of blue lupin is about the size of a pea, plump, rounded, and slightly kidney shaped (Fig. 35, p. 113). It measures about 8 mm. by 6 mm. The general colour is a buff grey, but there are numerous large fleckings of brown and yellowish-brown. The hilum is yellowish-white; on one side of it is a large triangular brown patch, and on the other a long, narrow, brown streak.

The seedling has a strong tap-root and pinkish hypocotyl. The cotyledons form a blunt crescent about half an inch long. They are thick, dark green, irregular on the upper surface, reddish below. The first leaf has 5 very narrow folded leaflets, bearing very short hairs (Fig. 25A).

The Yellow Lupin (*L. luteus* L.) branches even more than the blue lupin, and its basal branches are more horizontal. It reaches a height of from 2–3 feet. It does not make such rapid growth in the early stages as the blue species, and it is reputed to be more likely to cause poisoning than the blue lupin.

Its seed is slightly smaller than that of the blue lupin, and is flatter and less plump (Fig. 35). Its general colour is white, but it is liberally sprinkled with dark brown patches. There is a curved whitish streak running along each of the flattened sides not far from the hilum. The hilum is more closed than in the other species.

Uses. Lupins as a crop were well known to the ancient Romans. They are not much cultivated in this country, though on the Continent they are more widely grown. Since 1859 they have been grown regularly in parts of Suffolk, both for fodder and for seed as well as for ploughing in as green manure.

Lupins are essentially a crop for poor light land, especially land deficient in lime and therefore unable to support other leguminous forage crops. The species

most grown for folding-off by sheep in this country is the blue lupin, though years ago the yellow lupin was much favoured, and is still grown extensively on the Continent. The white lupin is usually used for green manuring only.

For fodder purposes blue lupins may be drilled from April to the end of July, using up to 2 bushels of seed per acre. Mixtures of one bushel of lupins, 2 lb. rape and 2 lb. white turnip seed per acre, or of one bushel of lupins and half a bushel of buckwheat, have also been successfully used in Suffolk. Lupins have also been mixed with oats and vetches. Manuring is not necessary for this crop.

Lupins are usually folded off by sheep, which are the only class of farm stock which will eat them. Silage has been successfully made from lupins, and also from a lupin-buckwheat mixture, but lupin hay is not made in this country.

Lupin Poisoning. It is important to begin folding the lupins gradually, and pregnant ewes should not be allowed a lupin diet. Lupins contain varying amounts of a poisonous alkaloid, which at times is present in sufficient quantity to cause the death of sheep through paralysis of the respiratory organs. Potassium permanganate and tea are said to be useful in cases of lupin poisoning. The danger of poisoning, in this country at any rate, is remote if the sheep are gradually accustomed to the lupins and are not allowed to gorge themselves. It is claimed from a German source that varieties of forage lupins are now available, which are practically free from the poisonous alkaloid, but so far these have not been tried out here.[1]

The blue lupin is the only species to ripen its seed

[1] For a detailed account of Lupin Poisoning consult "Plants Poisonous to Livestock," by H. C. Long (Cambridge Agricultural Monographs).

in this country; in a season favourable to this lupin from 15–20 cwt. of seed may be expected.

Chemical Composition. Becker gives the following percentage analyses of Lupin fodder, presumably the blue species. (Digestible nutrients in brackets.)

	Dry Matter	Crude Protein	Crude Fat	N-free Extract	Crude Fibre	Ash
Green, beginning of flower.	12·2	2·9 (2·2)	0·3 (0·2)	5·0 (3·1)	3·0 (2·2)	7·2
Green, end of flowering .	16·9	3·2 (2·1)	0·4 (0·2)	7·0 (4·0)	5·3 (3·6)	—
Straw . . .	84·0	6·5 (2·5)	1·4 (0·4)	30·8 (20·0)	41·4 (21·0)	4·06
Chaff . . .	85·0	6·8 (2·6)	0·7 (0·2)	41·5 (25·3)	30·1 (14·4)	—

MELILOT, OR SWEET CLOVER— GENUS MELILOTUS

General Characters of the Genus. White Melilot may be taken as typical of the genus. It possesses a long, stout, woody tap-root penetrating deeply into the soil. The stems are cylindrical, hollow and slightly ribbed. They may branch, especially at the base. At first they are bright green and succulent, but they soon become dull in colour, tough and woody. They may reach a height of 6 feet or more.

The leaves are very similar to those of lucerne (Fig. 26). They are trifoliate, on a foot-stalk not quite as long as the leaflets. The terminal leaflet is on a longer stalk than the lateral leaflets. The leaflets are narrow, more or less ovate, the margin slightly toothed at the apex, with a very slightly projecting mid-rib. In the vegetative state the plant may with certainty be distinguished from lucerne by the stipule. The stipule of the

melilot is small, narrow, triangular and sharply pointed, but the margin is not toothed, nor does the base expand as in lucerne.

FIG. 26.—White Melilot.
A, part of the plant; B, fruit.

The flowers are carried in long, loose one-sided racemes at the end of long axillary stalks. The flowers are white and flowering begins in July. The individual flowers are small, the upper, or younger ones, being erect in the bud stage, drooping later.

The calyx has a short tube, with sharply pointed teeth

as long as the tube. The standard petal is relatively large and broad: the wing- and keel-petals are almost as long as the standard. The ends of the wing-petals are widely separated. Wing-petals and keel-petals on each side adhere to each other a short distance beyond the claw. The stamens are diadelphous, the upper one being completely free. The style is distinctly longer than the stamens. The diploid number of chromosomes is 16 in *M. alba*.

After fertilization the fruit forms an oval, rounded pod which turns black as it ripens (Fig. 26B). Its surface is covered with a fine raised network. The pod contains one seed, which is released by dehiscence of the pod along one suture.

Seed and Seedling. The seed of melilot has a general resemblance to that of red clover, but the radicle and cotyledons are much more clearly defined (Fig. 34, p. 112). It is just over 2 mm. long by about 1·5 mm. wide. The colour is a brownish-yellow to a brown. Usually the cotyledons appear very plump and rounded, and between these and the radicle is a distinct depression. The radicle itself is usually plump and cylindrical.

The seedling has cotyledons about 8 mm. long by 3·5 mm. broad, elliptical, rather blunt at the ends: the stalks are 2 mm. long. The first leaf in outline resembles the old-fashioned straw beehive (Fig. 15C, p. 58). It has a slightly projecting mid-rib, and the veins are distinct on the upper surface. The margin is slightly toothed. The stalk is red in colour, slightly hairy, and the stipule is curved and has one tooth.

Cultivated Types. Three species of Melilot are cultivated for fodder purposes, chiefly in America: they are:

1. Common Melilot, *Melilotus officinalis* Lam. This is a yellow-flowered, biennial plant, used by the ancients

as a source of coumarin for medicinal purposes. This is a smaller species than the biennial white melilot. The stems are finer and more decumbent, the leaf is finer, and there are more tillers. It is liable to develop into a weed, and as its seed is dear this species is not much used.

2. King Island Melilot, *M. indica* All. (= *M. parviflora*). It is an annual species with yellow flowers. It gets its name from King Island, near Tasmania, where it was introduced about 1906, and was found very useful in developing the dairy industry. It is little used elsewhere except occasionally as a green manure.

3. White Melilot, *M. alba* Desr. This is the biennial, white-flowered melilot already described. An annual variety of this species (var. *annua*) is called Hubam.

White Melilot, Sweet Clover, Bokhara Clover, is now extensively grown as a fodder crop in the United States of America and in Canada. The plant was introduced into America at least as early as 1739, and for many years was regarded as a noxious weed, being particularly apt to give trouble during the first 2 years of a lucerne ley. Its long root opens up the sub-soil, whilst the flowers are greatly appreciated by bees, which make from it a light-coloured, slightly greenish honey. Its stems are liable to become coarse and woody, and owing to the bitter taste of the herbage stock take some time to become accustomed to it.

But cut at the right time sweet clover contains as much protein as lucerne. It can be cut for hay, or grazed.

The usual amount of seed sown per acre in America is 12–15 lb. per acre of the pure seed, or 20–25 lb. per acre of unmilled seed. Sometimes it is mixed with

grasses to reduce the chance of cattle becoming bloated. Seed is usually sown in a nurse crop, wheat, barley, oats or even flax. Inoculation of the seed is usually desirable if the land has never before carried the crop, and on account of the high percentage of hard seeds, scarification of the seed is also advisable.

The yield of seed is from 8–10 bushels per acre from a crop drilled in rows, or 3–5 bushels if broadcast.

Sometimes difficulty is experienced in eradicating the plants when it has been decided to plough up the root. If instead of tackling the job in autumn, ploughing is delayed until the plants have started to grow in early spring, the root can easily be destroyed.

Hubam. An annual variety of sweet clover called Hubam has been on the market since about 1920. In 1916 Professor H. D. Hughes of the Iowa Agricultural Experiment Station discovered certain white-flowered sweet clover plants which bloomed the first year: later, similar plants were discovered in Dakota, having sprung from Alabama seed. The composite name Hubam has been applied to this annual mutation.

Hubam (*M. alba* var. *annua*) is smaller and has a more woody root than the biennial sweet clover, but its foliage and seed are indistinguishable from it. During the year that the seed is sown hubam blossoms, sets seed and dies. In winter the biennial form usually has two or more crown buds on top of the root, together with a certain amount of dead tissue, and this usually makes it possible to distinguish between the two types. On the other hand, if as sometimes happens, only one crown bud develops on the root of the biennial form, distinction is almost impossible.

Experiments conducted between 1923–26 at Seale Hayne Agricultural College in Devonshire, at an altitude of 400 feet, indicate that Hubam is not so robust as the biennial melilot, especially in the early stages of growth.

The seedlings were very susceptible to attacks by the turnip flea-beetle. If cut before the stem hardens the yield is no greater than can be obtained from clover and other legumes.

Neither Hubam nor the biennial melilot have been much grown for fodder in this country. Possibly one reason is that the necessity for cutting early, before the stem hardens, has not been sufficiently realized. Success has been claimed for sweet clover when used as a green manure, particularly on the thin poor soils of the Breckland near Newmarket and Brandon, where good crops of oats have been grown on land otherwise unmanured.

Chemical Composition. According to a report (Bulletin No. 296) of the Ontario Agricultural College, the green leaf of white melilot at time of flowering contains the following percentages: dry matter 21·24; crude protein 6·6; crude fat 1·86; N-free extract 8·61; crude fibre 2·14. The stem is much more woody, containing crude protein 2·03; crude fat 0·62; N-free extract 8·73; crude fibre 11·89 per cent.

CHAPTER VII

PULSE CROPS SOMETIMES GROWN FOR FODDER

FIELD BEANS

(*Faba vulgaris* Moench)

Although beans were originally placed with vetches in the genus *Vicia*, the two plants are distinct: it is more convenient to regard beans as forming a separate genus, *Faba*, and the Field Bean is known as *F. vulgaris* (Moench).

General Characters. Beans are annual plants with characteristic square stems reaching the height of 4 feet or more. The stems are hollow, with strong "wings" at each corner, and are free from hairs.

The root from which the stem arises is a stout tap-root with five rows of lateral roots springing from it. The nodules are large and rounded, and are found both on the main root and its branches.

The leaves are alternate and consist of a number of opposite leaflets situated upon a deeply channeled common foot-stalk. There may be only one pair of leaflets, or as many as 4 pairs, each with its own short petiole.

The terminal leaflet is poorly developed, and can be seen as a small narrow structure at the end of the common stalk. Each leaflet is broad, elliptical, free from hairs, with a slightly projecting mid-rib and entire margin. Often the leaflets of each pair are not exactly opposite

each other. The stipules are winged and toothed as shown in Fig. 27.

Flowers arise in the axils of the leaves both near the base and at the tip of the stem. They are formed on racemes having 2 to 6 flowers. They are usually white except for a large black patch on each of the wing-petals.

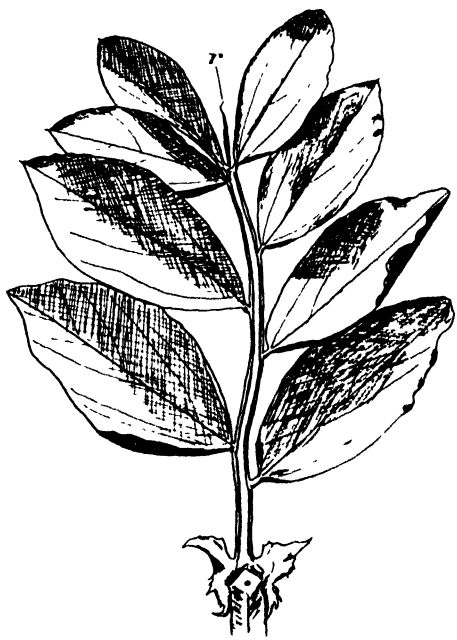

FIG. 27.—Leaf of Field Bean.
r, rudimentary terminal leaflet.

The structure of the flower of the bean has already been described on page 2. Cross pollination and fertilization through the agency of bees is common, with the result that varieties of bean are seldom pure.

Usually the pod, which is almost erect, contains several seeds, the number varying according to variety. The pod is at first green and shiny on the outside, whilst the inner lining is soft and woolly. As ripening proceeds

the pod becomes progressively drier and harder, and its woolly matter disappears. Eventually the pod turns black, becomes brittle, and splits open into two portions to release the seeds.

Seed and Seedling. Seeds of the field bean are very variable in size, shape and colour, but they differ from

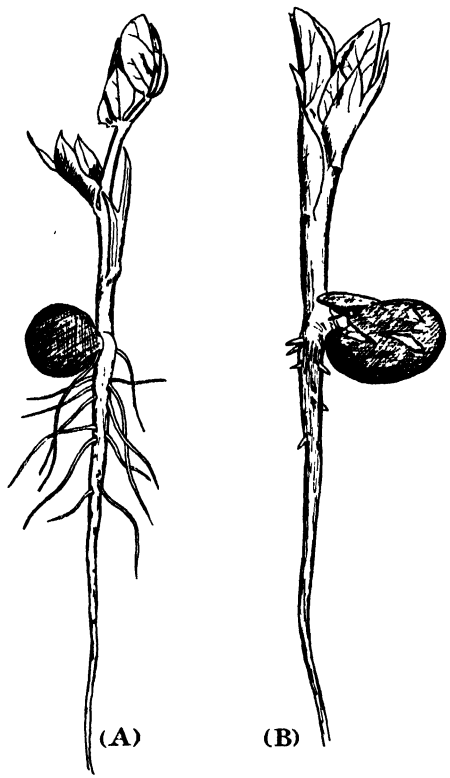

FIG. 28.—Seedling of A, Field Pea; B, Field Bean, at similar ages.

the Broad Bean of our gardens in being more rounded and considerably smaller. The smallest seed is formed by the so-called Pigeon Bean, which is a type of Tick Bean, or English Horse Bean. The Tick Beans are about half an inch long, buff or brown in colour (Fig.

35, p. 113). One characteristic shared by all the beans is the large hilum (Fig. 2B, p. 4), but attempts to classify beans according to this structure have not been very successful, since the colour of the hilum varies in a manner that is not well understood. The classification and recognition of beans by their seeds is, indeed, a very difficult, and sometimes impossible matter.

Germination is hypogeal; that is, the testa and cotyledons remain below ground (Fig. 28B). This is unusual, for the cotyledons of most seedlings come above ground and turn green, functioning as green leaves until the permanent leaves have developed. The seedling is characterized by a strong radicle, and a plumule which bursts through the soil in a bent position. The lowest leaf is small, sharply pointed and slightly toothed at the apex: the next leaf is often split up into 3 sharply pointed segments, the central one much narrower than the others. The leaf above this is compound, with broad, pointed stipules, a stout, short stalk, and a pair of tightly folded leaflets with a tiny, spike-like rudimentary leaflet in between. Usually 3 stems are produced from each seed, since a bud in the axil of each cotyledon develops shortly after the plumule has grown out.

Types of Field Beans. There are two types of field bean, Winter beans and Spring beans. Winter beans are hardy, and will usually stand the frosts of winter in the eastern and southern districts of England. They usually develop the secondary stems just referred to, have a more compact growth, and grow more slowly than Spring beans. Spring beans are not winter hardy, but they grow rapidly and flower at the same time as Winter beans. It is not possible to identify particular bean plants as Spring or Winter beans merely from their appearance. The difference is physiological, not morphological. There is no very considerable difference between the vegetative structure of the field bean and

the garden bean. Garden beans, such as the Broad Bean and Windsor Bean, have stouter and possibly more succulent stems. The seeds however are very different, for those of the garden varieties are flatter and broader and bigger than the more rounded, darker coloured seeds of the field bean.

Field beans undoubtedly do best on heavy land, but they will also succeed on lightish soils if there is an ample supply of moisture and lime.

Uses. Beans are used for soiling or for silage, mixed with vetches or peas. The beans, with their strong erect stems, provide support for the trailing stems of the other plants, and so enable a more successful crop to be grown. A mixture consisting of beans 1 bushel, Maple peas ½ bushel, vetches ½ bushel and Clemrotheray or Dun oats 2 bushels, has given heavy crops on strong land in the West Midlands, and at the same time smothered out annual weeds. On similar land in the Eastern Counties the following mixture has provided good silage: 1 bushel of beans, ploughed in with a shallow furrow, 1½ bushels of vetches and 1½ bushels of oats, drilled 3 weeks later.

Beans should be planted 2–3 weeks earlier than vetches, so that by the time the latter have burst through the soil the beans will be big enough to offer them some support.

VETCHES OR TARES—GENUS VICIA

According to Druce there are 12 species of vetch native to the British Isles, but other authorities state that the number is considerably lower. The only species cultivated to any worth-while extent as a farm crop in this country is the Common Vetch (*V. sativa* L.) which by some is thought to be a cultivated form of the Narrow-leaved Vetch (*V. angustifolia* Roth.).

Vetches are frequently called Tares, but they should not be confused with the Tares of the Bible, which are thought to have been Darnel (*Lolium temulentum* L.), a species of rye-grass.

General Characters. Cultivated vetches have a slender tap-root system with numerous strong branches.

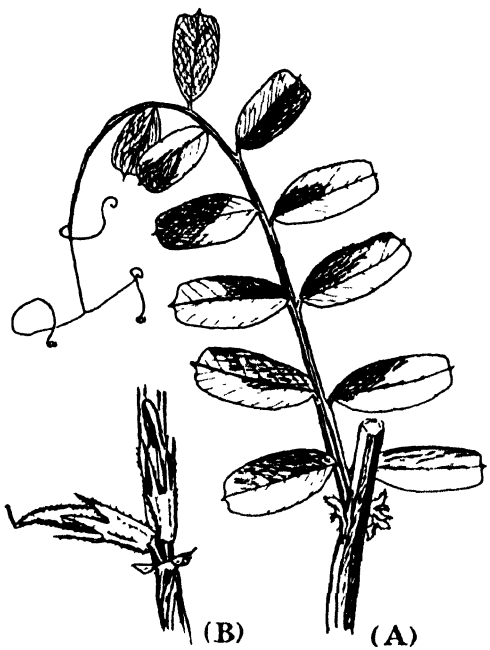

FIG. 29.—Leaf of Common Vetch.
A, showing tendrils and stipules; B, young fruits just after the fall of the corolla.

The nodules vary from the almost spherical to a cylindrical form 4 mm. or more in length, sticking out at right angles to the root. They are pinkish at the extremity.

The stem is long and weak, reaching a length of from 2–6 feet. Usually several of these stems arise by branching from the base of the plant. They are square

in section, hollow, and slightly winged at the corners, and downy.

The leaves are compound pinnate, and have 6 or 7 pairs of more or less opposite leaflets, and 2 or 3 pairs of tendrils at the extremity (Fig. 29). The common stalk is deeply channeled. The leaflets are oval, often squarish at the apex, with a distinctly projecting mid-rib. The margins are not toothed. Both surfaces are hairy, particularly the underside. The veins on either side of the mid-rib are oblique and almost parallel to each other.

The stipules are small and very much divided, clasping the stem. Some varieties have a purplish patch in the centre of the stipule.

The flowers are on very short stalks and are borne singly or in pairs in the axils of the leaves (Fig. 29B). The calyx is large, with broad teeth tapering to sharp points. The teeth are as long as the tube and both teeth and tube are hairy. The corolla is reddish-purple. The stamens are diadelphous. The fruit is a more or less hairy legume, with from 4 to 10 smooth seeds.

Seed and Seedling. The seed is round but flattened: it may have a diameter of about 4 or 5 mm. and a thickness of about 3 mm. In colour it is a very dark brown, almost black, with scattered black patches. The hilum, which runs along one of the edges, is 3 mm. long, very narrow, and light in colour (Figs. 2D, p. 4, and 35, p. 113). There is a distinct raised, roundish, black area—the strophiole (p. 3)—a millimetre or so distant from, and in line with, the hilum.

During germination the cotyledons remain buried in the ground, whilst the plumule forces itself to the surface. The first few leaves have only one pair of narrow leaflets, each with a small spine-like projection between them (Fig. 30). The root is relatively strong, with numerous side roots. Subsequent leaves have the form already

described. From lateral buds at the base of the stem and in the axils of the lower leaves, are produced the long trailing stems so characteristic of the plant.

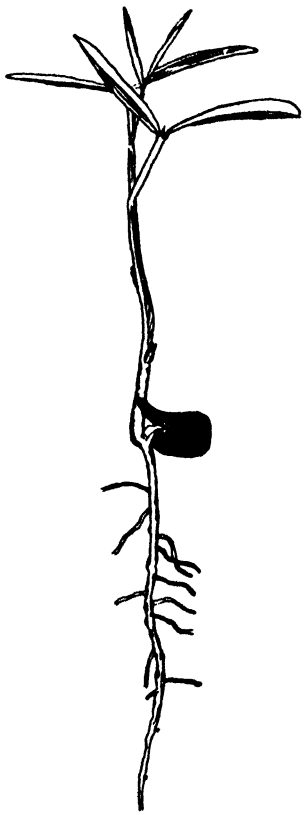

FIG. 30.—Seedling of Common Vetch.

Varieties. From a practical point of view it may be taken that there are three varieties of farm vetches, Winter, Spring and Summer vetches. The first two varieties belong to the species *V. sativa*, and they are so similar in their vegetative and seed characters that it is not possible to tell the one from the other. Physiologically, however, they are very dissimilar, since the winter variety is sufficiently hardy to survive the frosts of winter, which would destroy the spring vetch. The summer vetch, also called the Goar vetch, resembles the winter and spring vetches, but it is a larger plant with larger seeds and a shorter growing period.

Because of these different varieties it is possible to obtain a succession of vetch crops during a large part of the summer by sowing the different seeds at pre-determined times.

Uses. As a fodder crop vetches can be used for folding sheep, for cutting green and soiling to stock, for silage and for hay. Vetch hay is difficult to make because the stems are so succulent that a long period of dry weather is necessary to cure them. Vetches

should be cut when in flower if they are to be made into hay, and a yield of up to 3 tons per acre of hay may be expected.

For whatever purpose vetches are grown it is usual to mix the seed of some upright-growing plant with the vetch seed, so that the trailing stems of the vetch may receive some support. A mixture of 1½ bushels of vetches and 1½ bushels of a leafy oat is very successful. Beans and rye may also be used. Winter vetches are best mixed with winter oats, and sown in October, since rye is inclined to become too tough. Spring vetches are mixed with spring oats, and sown from February onwards.

Vetches will grow on most soils if there is an adequate supply of lime. They are often not manured, and like other leguminous crops, they enrich the soil with nitrogen. Nevertheless the application of phosphatic and potash fertilizers definitely increases the yield of fodder. Oldershaw recommends 2–3 cwt superphosphate, and 1 cwt. of muriate of potash or 4 cwt. of kainit on lighter soils, and on heavy soils 6 cwt. of basic slag or 4 cwt. superphosphate as suitable dressings for forage vetches.

PEAS—GENUS *PISUM*

Two species of Pea are grown in this country, the Field Pea (*P. arvense*) and the Garden Pea (*P. sativum*). These two species are very much alike in appearance except for the flowers, which in garden peas are white and in field peas are purple, and the seeds, which in garden peas are yellowish-white or bluish in colour against the brownish seeds of field peas. Field peas are hardier than garden peas.

General Characters.

The Field Pea (*P. arvense* L.) is an annual plant with a strong tap-root and numerous stout lateral roots.

The nodules on the main root are large, and frequently tri-lobed, each lobe being 5 mm. or more long: on the younger roots the nodules are sausage-shaped, and attached by the end to the root (Fig. 3A, p. 6).

The stem is usually angular, sometimes almost round, and hollow. It is quite incapable of remaining upright without support. It is free from hairs, and covered with a waxy bloom which easily rubs off.

FIG. 31.—Leaf and flower of Field Pea. *s*, stipule; *t*, tendril.

The leaves are composed of 2 or 3 pairs of opposite leaflets, together with one or more pairs of tendrils, which are really modified leaflets. There is also a terminal tendril. The leaflets are usually broad and ovate. The veins are very distinct and the mid-rib projects as a fine point: the margin may be entire, or slightly toothed. At the base of the leaf are the stipules, which in the pea are relatively enormous (Fig. 31). Their margins are toothed at the base, and there is a purplish coloration where the stipule touches the stem. This serves to distinguish field peas from garden peas, for in the latter there is no such coloration.

Flowers are borne at the end of long, stout, axillary

stalks: usually only 1 or 2 flowers are carried on each peduncle. The calyx has a wide tube, and broad, sharply pointed teeth. The corolla is purple or lavender: the standard is usually lighter coloured than the wing-petals, which have a deeper red. The stamens are diadelphous, the posterior one being free from the other 9. The fruit is the well-known pod, containing several seeds. Peas are self-fertile.

Seed and Seedling. Seeds of the field pea are large and round, but individual seeds are often more or less flattened where they have been crowded together in the pod. They are about ¼ inch in diameter. In colour they are brown, dun, or grey with fine spots, not yellow or green like those of garden varieties. The flesh inside the seed, however, may be yellow. The Partridge pea and the Maple pea have pale brown seeds flecked with dark spots. The hilum is relatively much smaller than it is in the field bean (Fig. 2c, p. 4).

During germination the cotyledons and seed coat remain below ground, the plumule appearing above ground after the manner of the bean seedling (Fig. 28A). As in the field bean, the lowest leaf is sharply pointed and simple. The second leaf, too, has 3 segments, though these are not so distinct. The next leaf has relatively enormous stipules, and a single pair of tightly folded leaflets, with a spine-like rudimentary terminal leaflet. The green parts of the seedling are appreciably smaller than those of the bean.

Uses. Peas like a lighter soil than beans, and lime is essential. When grown in the ordinary way for their seed, peas are often a difficult crop, since they are very susceptible to climatic conditions. Very wet and very dry seasons mean poor crops, and aphides often damage the plant beyond recovery. In soiling and silage mixtures, however, where the plants are cut green long before the seeds get hard, these disadvantages are not usually felt.

Peas must be mixed with either beans or a cereal for support. Oats are better than wheat, barley or rye, especially if a leafy type of oat is chosen. Pea and oat hay can be secured by sowing a mixture of 1 bushel of peas and 2 bushels of oats at the rate of 3–4 bushels per acre. Clemrotheray, Sandy, or similar straw producing oats should be used in preference to large-seeded oats, which are not suitable. Maple or Dun peas can be used.

Sowing must be made early, February to March. On light soils it is best to broadcast the seeds and plough them in about 3 inches deep: on stiffer land it is recommended to broadcast the seeds over the ploughed land, harrow in with a spring-tined harrow, and finish off with the heavy roller. A dressing of 3–5 cwt. of superphosphate at time of sowing is very beneficial.

Pea and oat hay should be cut when pods have formed on the peas, but before the seeds have filled out. It must be cured in large cocks before being stacked, since heating in the stack is deleterious to this type of hay. The peas are very liable to go mouldy if stacked at all wet.

The yield should be from 2–3 tons of hay per acre.

SOYA BEAN—GENUS GLYCINE

(*Glycine Max* L. (Merrill) = *Soya Max* (L.) Piper)

This plant, at one time known as *G. hispida*, is now classified as *G. Max* L. (Merrill) according to the international rules of botanical nomenclature, but in America is recognized as *Soya Max* (L.) Piper.[1]

General Characters. The Soya bean is an annual plant with a tough tap-root and numerous lateral roots spreading through the surface layers of the soil. The base of the stem is shrubby and hard: it sends up several

[1] For an exhaustive account of the nomenclature of the Soya Bean see "The Soya Bean," by Piper and Morse, 1923 (McGraw Hill Pub. Co.).

long, almost erect, stems to a height of from 2–4 feet. These are round in section and hairy.

The leaves are trifoliate. The terminal leaflet is separated from the laterals by a longish portion of the common leaf-stalk. Each leaflet has its own short thick petiole, at the base of which is a pair of tiny, pointed,

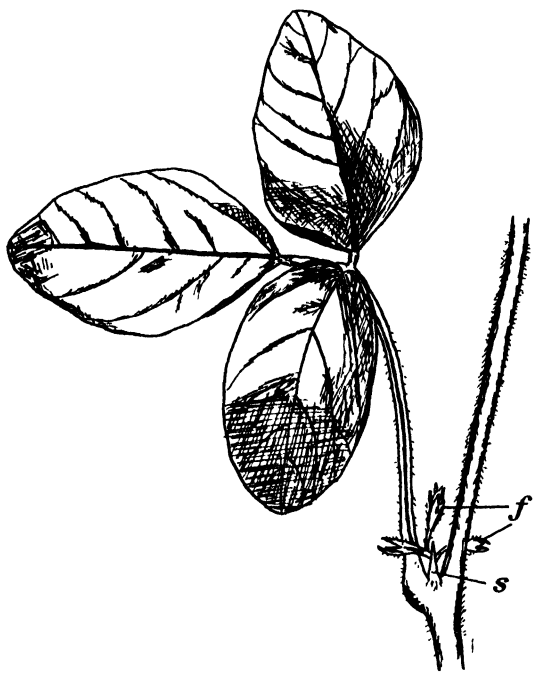

FIG. 32.—Soya Bean leaf showing stipule and flowers.
s, stipule; *f*, flower.

bract-like leaves resembling stipules (Fig. 32). The leaflets are large, ovate, hairy, and the mid-rib projects as a tiny point. The common leaf-stalk is hairy and deeply channeled on the upper surface. It is distinctly swollen at the base and has 2 small erect pointed stipules. Frequently the leaf-stalk makes a very acute angle with the stem. The leaves drop off as the pod ripens.

Flowers are borne in the axils of the leaves. Each flower has its separate stalk. In the axils of the lower leaves the flowers may spring individually: in the upper axils the flowers, 8 to 14 in a cluster, may be carried on a common stalk in a similar manner to those of the broad bean. They are first formed low down on the plant and then develop successively to the top. They all develop within a period of about 2 to 3 weeks, so that there is little difference in time of ripening of the pods.

The flowers are relatively very small, only $\frac{1}{3}$ inch long. There is a pair of small bracts at the sides of the flower. The calyx is very hairy, and the lowest tooth is longer than the others. The corolla is white or purple and inconspicuous. The standard is broad, with a short claw. The wings are wide apart at their apices, with a relatively short claw and long, broad expanded portion, with a narrow, backwardly projecting, finger-like process. The keel-petal is broad. The stamens are diadelphous, the free stamen having a relatively wide base to the filament. The ovary is bottle-shaped, hairy, with a short tapering style and knobbed stigma.

The soya bean is completely self-fertile, and is normally self-pollinated, since pollen covers the stigma almost as soon as the flowers open. Bees and other insects visit the flower, but chiefly for the pollen, since there is very little nectar.

Usually from 3 to 5 pods ripen out of each cluster of flowers, and from 40 to 60 pods develop per plant. The pod is about 2 inches long, laterally compressed, containing 3 to 5 seeds.

Seed and Seedling. Seeds of the soya bean are very variable in size and colour. The general shape is spherical or rounded oval, and the colour varies from a black to a yellow, from a green to a dark brown. Some idea of the differences in the size of soya bean seed may be gathered from a report of the University of Illinois

Agricultural Experiment Station (Bulletin 384). Of 26 varieties examined the average weight per 1,000 seeds was 139·2 grammes, with a variation between 49·7 grammes and 188·7 grammes per 1,000. The official bushel weight in the United States of America is 60 lb.

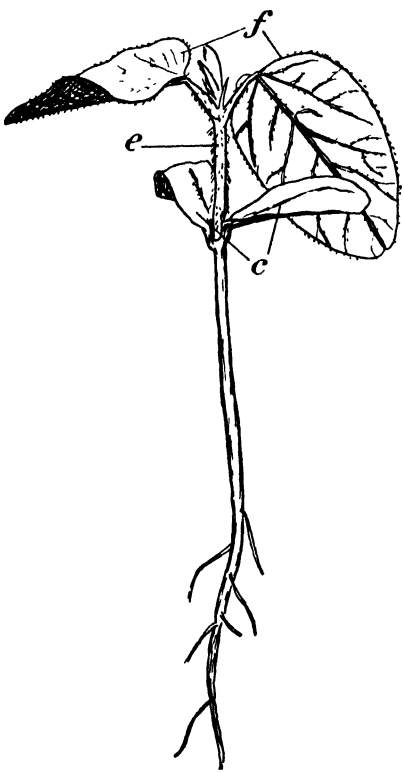

FIG. 33.—Soya Bean seedling.
c, cotyledon; *e*, epicotyl; *f*, first leaves.

The seedling has a strong tap-root and a long stout hypocotyl. The cotyledons are brought above ground, and are large and fleshy, somewhat like those of a lupin. The epicotyl, or stem above the cotyledons, is hairy, and the first formed true leaves are opposite and at right angles to the plane of the cotyledons (Fig. 33). They are simple and ovate, with distinct veins. The leaf is hairy, especially along the veins on the underside. Buds form in the axils of the cotyledons and lower leaves.

History and Uses. Soya beans were first described in an ancient Chinese work on *materia medica* of 2838 B.C., and there is reason to believe that the plant has been cultivated for over 5,000 years. The plant is indigenous to China, Korea, Japan and other eastern countries, but was not known in Europe until 1712: it was brought to

England as a curiosity in 1790, and was reported growing in parts of the north of America in 1829.

As a crop soya beans have only been of real importance in the United States since 1910: they are cultivated to a slight extent in Hungary and Czechoslovakia. In England attempts have been made repeatedly to grow soya beans for seed, but with little success. The climate is too wet in an average season to allow remunerative amounts of seed to mature, even in the case of varieties which, it is claimed, have been acclimatized.

The seed of soya bean is extremely valuable. It contains an oil which is rich in lecithin and vitamin A, and in one form or another the seed forms an important article of diet for millions of people. From the seed, too, is manufactured a bewildering number of different products, varying from linoleum to printing ink.

Soya beans are extensively grown for fodder purposes in the United States, and are used as hay, pasture or silage, or are cut green and soiled. So far, very few experiments have been conducted in this country to determine the value of soya beans as an additional fodder crop, but it seems probable that soya beans are more likely to be successful as a green crop than as a seed crop. A leguminous forage plant which could be sown and harvested within a period of 3 to 4 months should prove a valuable addition to our existing crops.

Soya beans give a hay of a higher feeding value than red clover hay, and will grow on land too acid to support the clover.

Seed should be inoculated before sowing, and must not be planted deeper than about one inch. From one to two bushels of seed per acre are required, according to the variety used.

For hay soya beans are cultivated in rows from 6–30 inches apart. The closer the rows the finer-stemmed is the hay, but wide spacing permits thorough

cultivation, which is very necessary if the land is at all weedy. Soya beans are easily crowded out by weeds and should only be sown on clean land. When above 2 inches high they will stand a lot of rough treatment, and the cultivator should be freely used to keep down weeds.

In America soya beans are cut for hay when the pods are well formed. Probably in this country it would be desirable to cut earlier than this. Preliminary experiments carried out at Harper Adams Agricultural College in Shropshire from 1925–28, gave a yield of green fodder at the rate of 7 tons per acre.

Chemical Composition. Borst and Thatcher state that the percentage of crude protein in the soya bean plant varies from about 22 per cent early in July to 17·5 per cent early in August, after which date it again rises to 22·7 per cent in late September. The percentage of nitrogen in the leaves and stem decreases by one-half and two-thirds respectively as the plant matures. The green parts contain approximately 0·25 to 0·30 per cent phosphorus and 1·3 per cent calcium.

SEED STATISTICS

Species	Weight per 1,000	Bushel Weight (lb.)	Number per lb. (1,000)	Reasonable Standards Purity	Germin.	Hard Seeds
	grammes.					
Red Clover	1·773	63	250	96	79	5
Alsike Clover	0·734	64	618	95	80	6
Dutch White Clover	0·612	65	740	94	82	7
Wild White Clover	0·557	68	814	92	75	13
Crimson Clover	3·412	64	133	96	81	—
Yellow Suckling Clover	0·510	66	890	97	76	15
Subterranean Clover	5·907	60	76	97 [1]	77 [1]	15 [1]
Strawberry Clover	1·683	62	270	95 [1]	74 [1]	21 [1]
Lucerne	2·059	62	220	97	81	6
Yellow Trefoil	1·620	64	280	98	76	3
Birdsfoot Trefoil	1·157	65	392	99	90	— [5]
Greater Birdsfoot Trefoil	0·520	64	872	87–91	63–77	10
Kidney Vetch	2·272	63	200	93	78	3
Sainfoin (in husk)	23·684	25	19	96	72	2
Sainfoin (milled)	15·232	56	29	96	72	1
Burnet	7·205	25	63	70	90	—
Blue Lupin	150–195 [2]	62	2·0–2·35	98 [2]	78 [2]	— [5]
White Lupin	340–520 [2]	62	0·87–1·33	97 [2]	62 [2]	—
Yellow Lupin	110–190 [2]	62	2·4–4·1	98 [2]	70 [2]	—
White Melilot	2·532	62	180	93	65–70	4
Field Bean	568·	65	0·8	98	95	—
Vetch (Common)	60·	63–65	7·5	97	89	— [5]
Field Pea	206–237	60–65	2·2	99	88	—
Soya Bean	49–188 [3]	60 [4]	2–9	99 [2]	85 [2]	—

Notes: The figures in Column 1 are, except where stated to the contrary, reproduced by permission of the Official Seed Testing Station for England and Wales.

Figures for Column 3 are calculated from Column 1.

[1] Based on N.Z. Seed Testing Station Report for 1934.

[2] See Becker, J., "Handbuch des Hülsenfruchterbaues und Futterbaues."

[3] The average of 26 varieties examined at the University of Illinois Agricultural Experiment Station was 139·2 grammes.

[4] Official U.S.A. standard.

[5] Hard seeds sometimes occur in these species.

Season, of course, affects the quality of seeds very considerably at times.

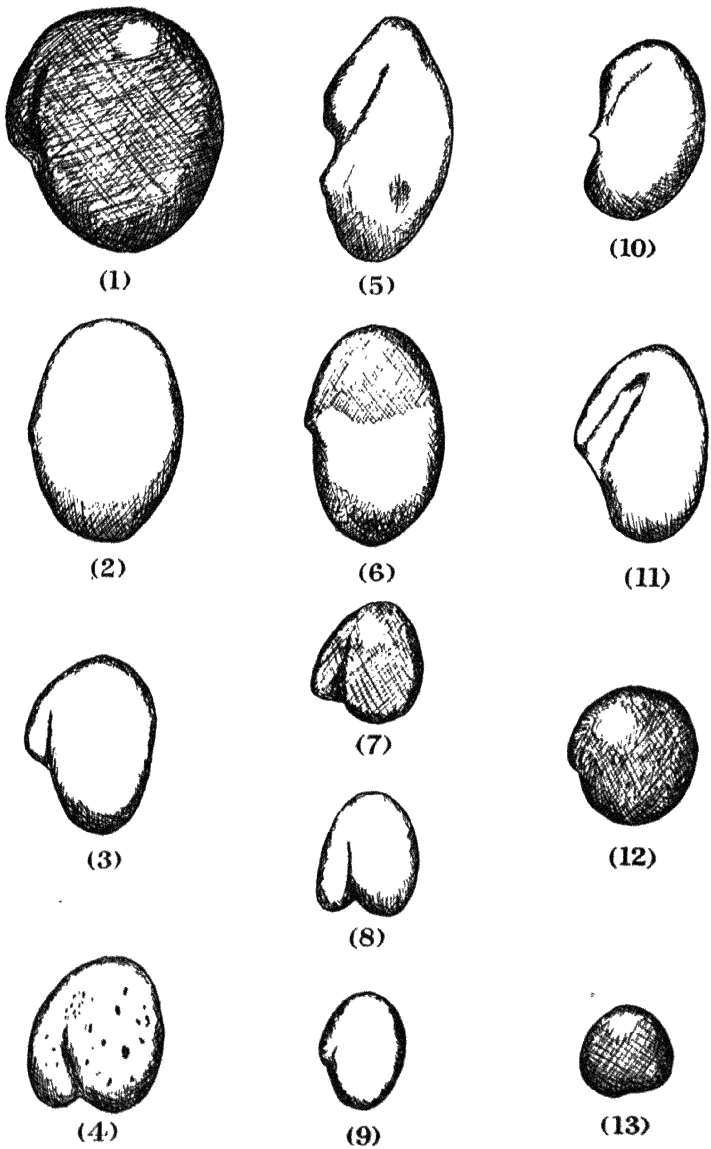

FIG. 34—Seeds of clovers and allied species.

1, subterranean clover. 2, crimson clover. 3, red clover. 4, strawberry clover. 5, lucerne. 6, kidney vetch. 7, alsike clover. 8, white clover. 9, yellow suckling clover. 10, yellow trefoil. 11, white melilot. 12, common birdsfoot trefoil. 13, greater birdsfoot trefoil. (*Enlarged approximately 12 times.*)

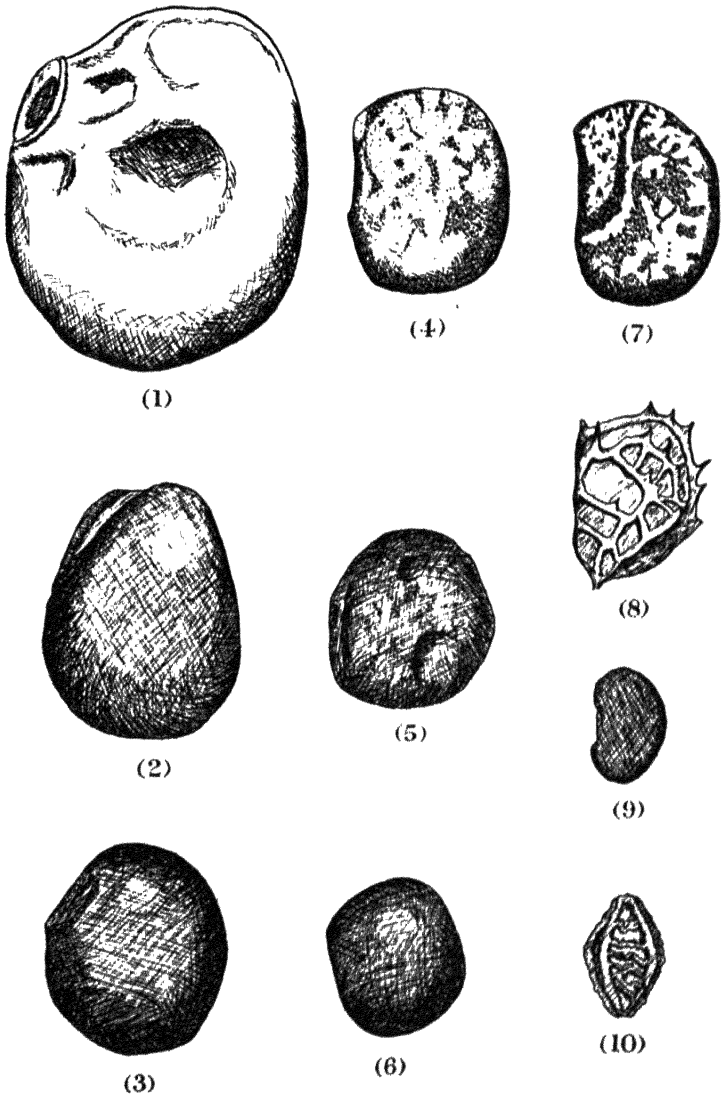

FIG. 35.—Seeds of other leguminous forage plants.

1, white lupin. 2, field bean. 3, soya bean. 4, blue lupin. 5, field pea. 6, common vetch. 7, yellow lupin. 8, sainfoin (in husk). 9, sainfoin (milled). 10, burnet. (*Enlarged approximately 3 times.*)

Aftermath. The second growth after the removal of a hay crop.

Andrœcium. The stamens regarded as a whole.

Anther. The knob-like part of a stamen which produces pollen.

Axil. The upper angle between a leaf and the stem.

Axillary. Arising in the axil.

Calyx. The green leaves at the base of a flower.

Carpel. In Leguminosæ the carpel and pistil (q.v.) can be regarded as one and the same.

Chromosome. A small structure which appears in the nucleus during division; thought to play an important part in heredity.

Corolla. The brightly coloured part of the flower, made up of petals.

Cyanogenesis. The act of producing hydrocyanic acid gas, often called prussic acid gas.

Cyanophoric. Capable of producing prussic acid gas.

Dehiscence. Method of splitting or opening out of a fruit.

Diadelphous. Having 9 stamens united into a sheath, and the tenth stamen free.

Diploid. The number of chromosomes occurring in the ordinary nucleus of plants.

Entire. Without marginal divisions.

Epicotyl. That part of the stem of a seedling immediately above the cotyledons which bears no leaves.

Gigas Mutation. A variety in which all the parts are much bigger than the normal.

Glabrous. Free from hairs.

Gynœcium. See Pistil.

Haploid. The number of chromosomes in a reproductive nucleus, half the diploid number.

Hilum. The scar on a seed left when it falls off its stalk.

Hydrogen-ion Concentration. A scale for measuring soil acidity. pH_7 represents a neutral soil; $pH_{3.8}$ a very acid soil, and so on.

Hypocotyl. That portion of a seedling below the cotyledons and between them and the true root.

Hypogeal. Keeping its cotyledons below ground.

Inflorescence. A collection of flowers on a common stalk.

Legume. The characteristic fruit of the Leguminosæ, a pod which normally splits open along two sutures (q.v.).

Micropyle. A tiny hole in the seed coat close to the hilum.

Monadelphous. Having all 10 stamens united into a sheath.

Mucronate. Having the mid-rib of the leaf projecting as a small, sharp point.

Ovate. Shaped like an egg.

Ovule. The small bodies in the ovary which turn into seeds.

Palmate. Having leaflets radiating from a centre.

Peduncle. Stalk of a flower.

Petiole. Stalk of a leaf.

*p*H. Hydrogen-ion concentration (q.v.).

Pistil. The female part of a flower, consisting of an ovary with a style and stigma.

Pyxidium. A single seeded fruit which splits transversely, as in red clover.

Raceme. A type of inflorescence in which the flowers are arranged spirally on an axis, each with its own stalk.

Soiling. A method of stock feeding where the crop is cut green and carted to animals in buildings.

Stipule. A small leaf attached to the base of the stalk of a foliage leaf.

Strophiole. A small spot or raised portion close to the hilum of a seed.

Suture. A line of junction in a fruit along which splitting takes place.

Symbiosis. A partnership, such as that between the root nodule organisms and leguminous plants.

Testa. The seed coat.

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